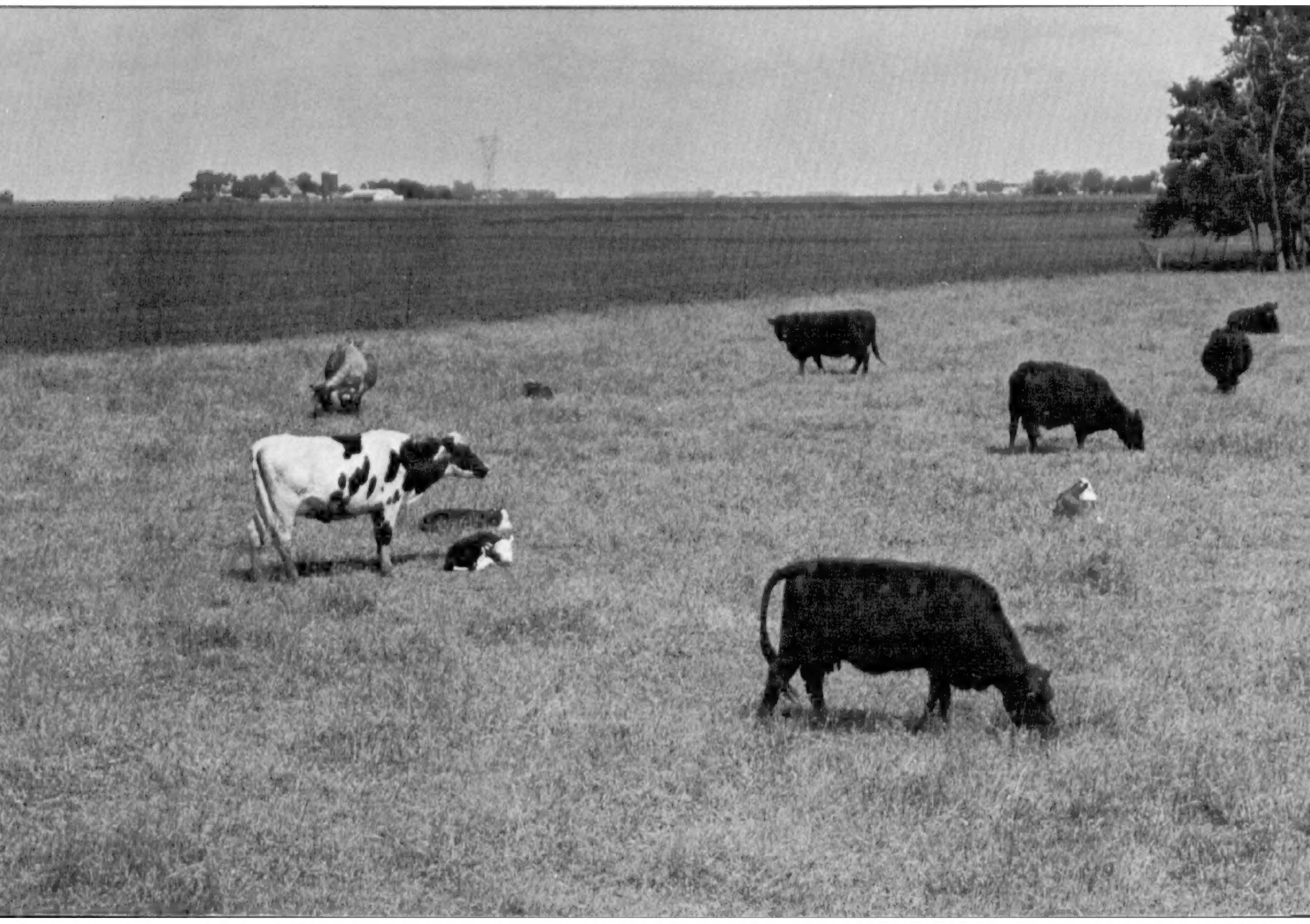
Soil Survey of

O'Brien County, Iowa

United States Department of Agriculture, Soil Conservation Service
in cooperation with
Iowa Agriculture and Home Economics Experiment Station
Cooperative Extension Service, Iowa State University, and
Department of Soil Conservation, State of Iowa



HOW TO USE

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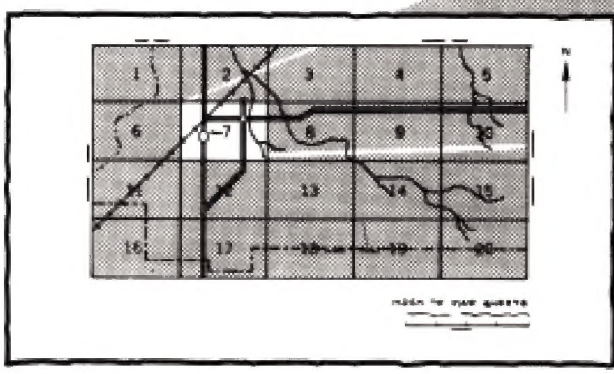

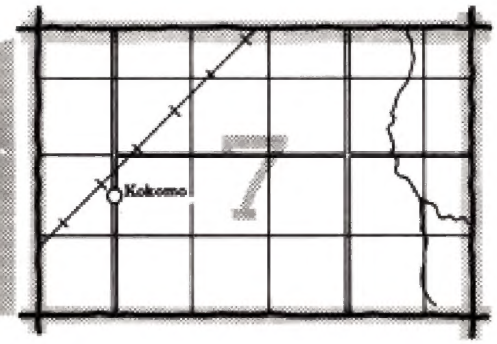

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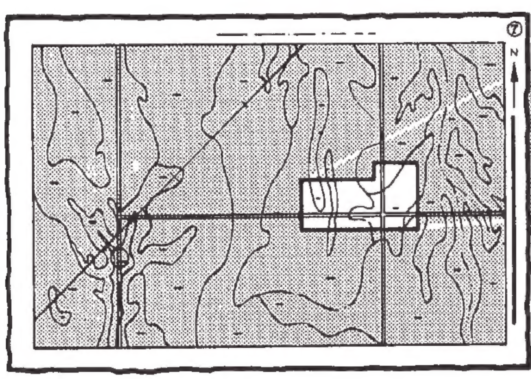

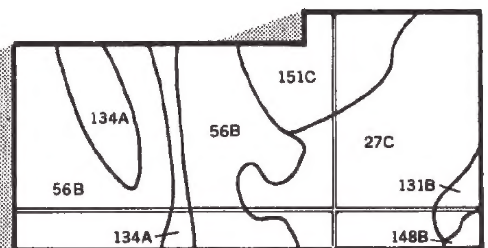

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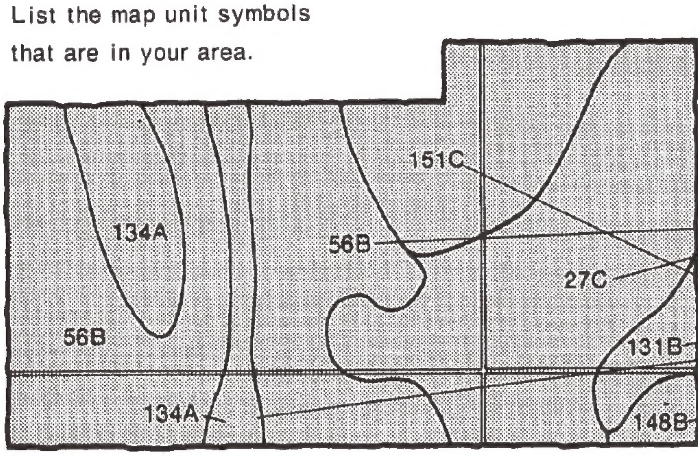

Symbols

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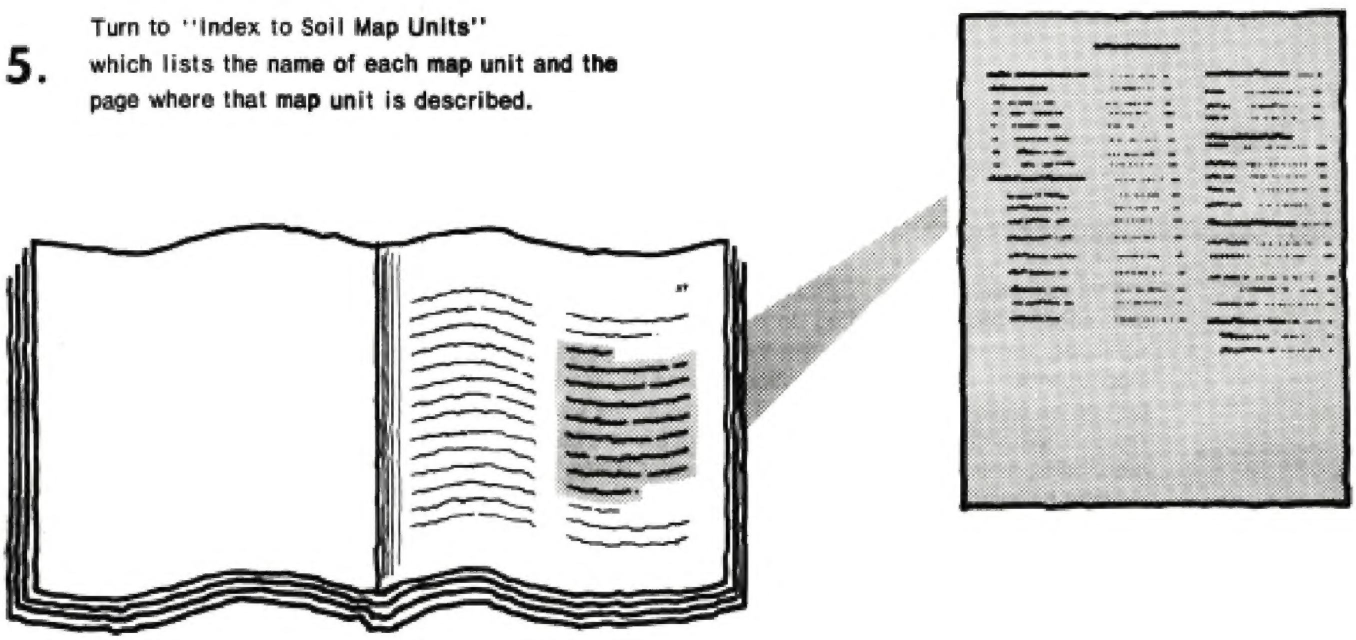
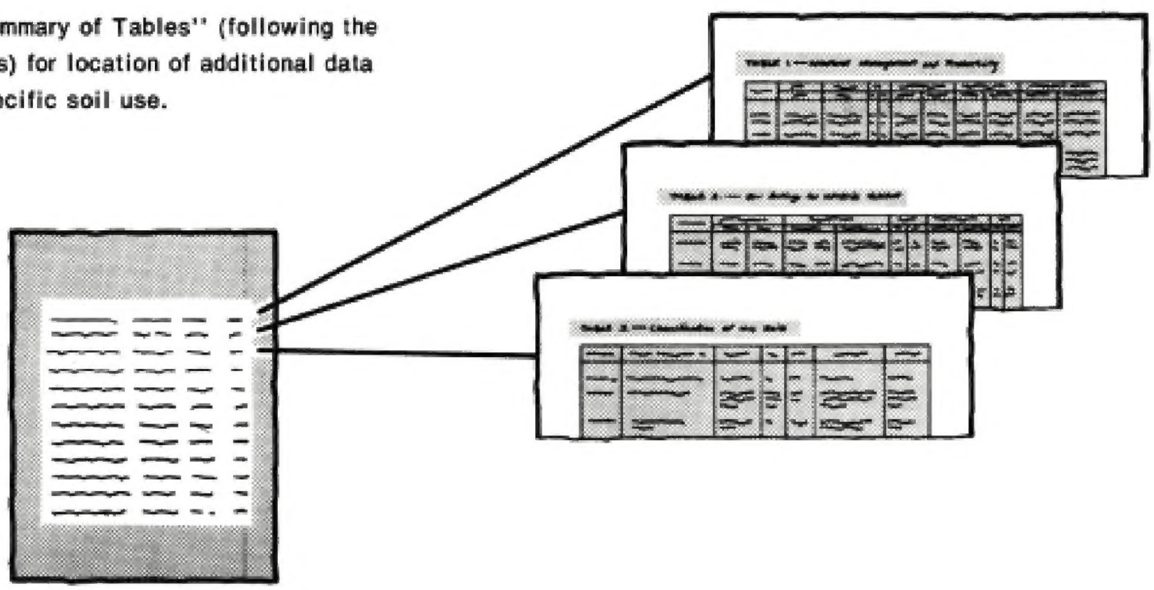
THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service; and the Iowa Agriculture and Home Economics Experiment Station; the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the O'Brien County Soil Conservation District. Funds appropriated by O'Brien County were used to defray part of the cost of the survey.

Major fieldwork was performed in the period 1972-75. Soil names and descriptions were approved in 1977. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1976.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

This survey supersedes the soil survey of O'Brien County, Iowa, that was published in 1924 (*27*).

Cover: Smooth bromegrass pasture on Marcus and Primghar soils.

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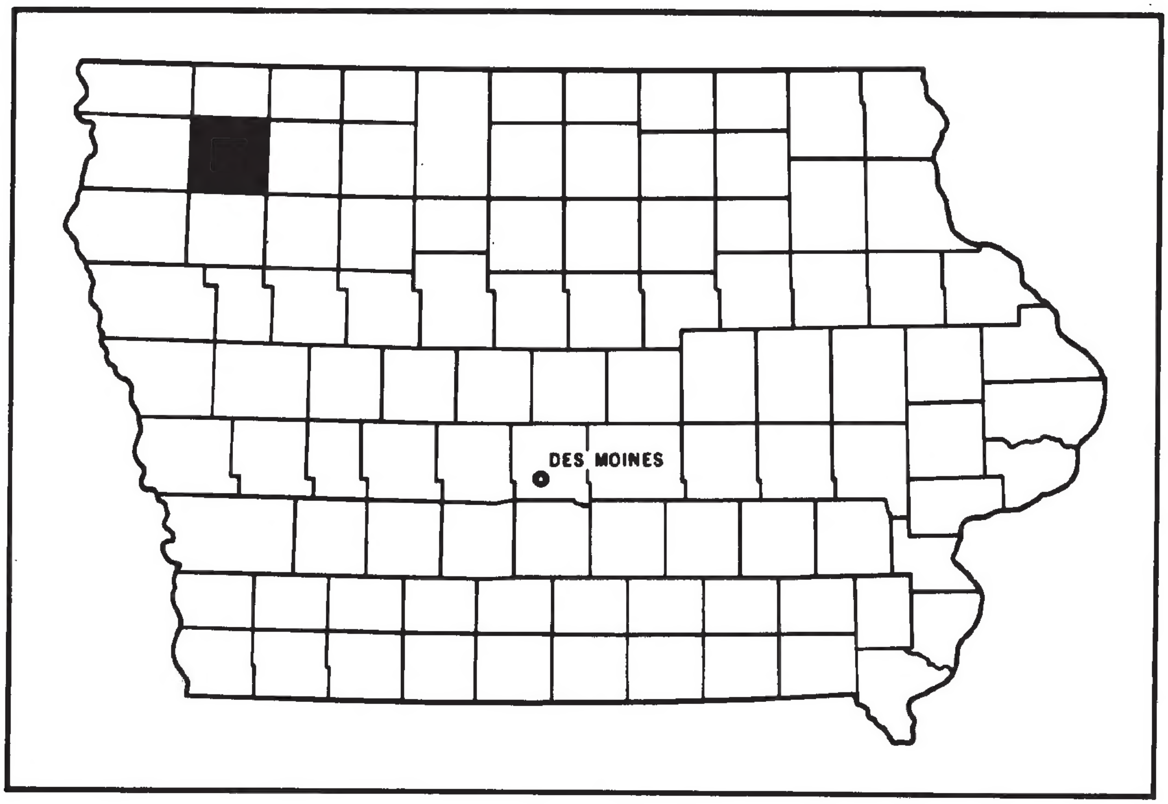
preface

This soil survey contains information that can be used in land-planning programs in O'Brien County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations inherent in the soil or hazards that adversely affect the soil, improvements needed to overcome the limitations or reduce the hazards, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are underlain by sand and gravel at a shallow depth. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.



Location of O'Brien County in Iowa.

soil survey of
O'Brien County, Iowa

By Wayne N. Dankert, Laurence T. Hanson, and Ronald L. Reckner,
Soil Conservation Service

Fieldwork by Wayne N. Dankert, Laurence T. Hanson, Harvey A. Harman,
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United States Department of Agriculture,
Soil Conservation Service, in cooperation with
Iowa Agriculture and Home Economics Experiment Station;
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general nature of the survey area

The climate, history and development, and cultural features of O'Brien County are discussed in this section. The climate and the distribution of soils in the county have affected the pattern of development in the county and the kinds of cultural features and their location. The effect of climate on the soils in the county is discussed under "Formation of the soils."

O'BRIEN COUNTY is in northwestern Iowa. It is in the second tier of counties south of Minnesota and in the second column of counties east of the Big Sioux River, which is the approximate Iowa-South Dakota boundary. The total area is about 57 square miles or 367,935 acres. The population is about 17,500.

The landscape of the county is characterized by well developed surface drainage except on the major drainage divides. The soils generally are deep, silty, and nearly level to gently sloping. The elevation ranges from 1,190 to 1,576 feet above sea level.

Farming is the main enterprise in the county. Corn and soybeans are the main crops. Cattle and hogs are raised on many farms, and dairying is important in some parts of the county.

climate

Prepared by the National Climatic Center, Asheville, North Carolina.

O'Brien County is cold in winter and hot in summer. There are occasional cool spells in summer. Precipitation in winter frequently occurs as snowstorms. In summer, warm moist air moves in from the south and showers, which are often heavy, result. Total annual rainfall is normally adequate for corn, soybeans, and small grains.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Sanborn, Iowa, in the period 1951 to 1974. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 18 degrees F, and the average daily minimum temperature is 9 degrees. The lowest temperature on record, which occurred at Sanborn on January 15, 1972, is -33 degrees. In summer the average temperature is 71 degrees, and the average daily maximum temperature is 83 degrees. The highest recorded temperature, which occurred May 25, 1967, is 102 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50

degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 27 inches. Of this, 20 inches, or 74 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 4.83 inches at Sanborn on September 7, 1964. Thunderstorms occur on about 46 days each year, and most occur in summer.

Tornadoes and severe thunderstorms occur occasionally. These storms are local and brief. They cause scatterd damage in narrow belts. Hailstorms occur during the warmer part of the year in an irregular pattern and in relatively small areas.

Average seasonal snowfall is 43 inches. The greatest snow depth at any one time during the period of record was 37 inches. On an average of 20 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 81 percent. The sun shines 72 percent of the time possible in summer and 54 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 13 miles per hour, in April.

history and development

The Mill Creek Indians farmed the area that is now O'Brien County in about 900 A.D. (*3, 14*). They grew corn, beans, and squash near their fortified villages along the major streams. They remained in the area until about 1600. Probably an extended drought forced them to leave. The Plains Indians used this area as a hunting ground from about 1600 until they were displaced by settlers in the period 1856-72 (*15*).

O'Brien County, named after an Irish patriot and revolutionary figure, was established in 1850. Primghar became the county seat in 1872. By 1914 the county population was about 17,000 (*14*).

Until about 1880 the main crop was prairie hay, which was shipped to Chicago and other eastern markets. Local use was made of the native trees on hillsides and on bottom lands along the larger streams. Wheat, oats, and flax were the first cultivated crops, but corn soon became the major crop.

Relatively large areas were not cultivated because of excessive wetness. As drainage tile was installed and drainage ditches were constructed, mainly after 1910, more of the poorly drained soils were cultivated. In recent years the increase in row crop acreage has been mostly on soils on bottom lands, where flooding is a hazard, and on moderately to strongly sloping soils on hillsides, where erosion is a hazard.

Since O'Brien County was settled, the total acreage in farms has remained fairly constant. The number of farms has been decreasing, however, and the average size of farms has increased. The number of farms was 1,908 in 1923 (*25*); 1,759 in 1962; and 1,376 in 1974. The average size of a farm was 184 acres in 1923, 204 acres in 1962, and 259 acres in 1974.

In O'Brien County, many of the soils are nearly level and gently sloping. These soils are well suited to crops, and they are commonly used for this purpose. More corn is raised than any other crop, but the acreage of soybeans has increased in recent years. From 1969 to 1974, farmland used for soybeans increased from 22 to 30 percent. The acreage of crops in 1974 was as follows: corn, 167,500 acres; soybeans, 116,500 acres; pasture and woodland, 22,248 acres; hay and grass silage, 11,900 acres; oats, 13,600 acres; and wheat, 270 acres (*23*).

Much of the crop production is fed to farm livestock. In recent years, the number of dairy cattle and poultry has decreased and the number of fed cattle and hogs sold has increased. Livestock sales in 1974 were as follows: fattened cattle, 70,100; hogs, 251,800. In 1974 there were 9,300 beef cows, 4,700 milk cows, 163,000 hogs and pigs, and 83,000 hens and pullets of laying age on farms in O'Brien County (*23*).

cultural features

The population of O'Brien County is approximately 17,500 (*26*). Sheldon, the largest town, has a population of about 4,500. Hartley, Paullina, Primghar, Sanborn, and Sutherland have populations of 800 to 2,000 (*11*). There are a number of smaller communities.

Two federal and four state highways cross O'Brien County. There are numerous all-weather-surface county roads. Gravel roads follow most section lines.

Three railroads and one bus company provide service to the county. Sheldon and Hartley have municipal airports where charter flights are available.

Agriculture, including farming and related activities, is the principal industry in the county. Food processing and farm equipment manufacturing in and near the county are important sources of employment and income.

There are colleges within 50 miles of the county, and there is a state vocational school west of Sheldon. The county has five high schools, and there are hospitals in Hartley, Primghar, and Sheldon.

how this survey was made

Soil scientists made this survey to learn what soils are in the survey area, where they are, and how they can be used. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; the kinds of native plants or crops; and the kinds of rock. They dug many holes to study soil profiles. A profile is the sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent

material, which has been changed very little by leaching or by plant roots.

The soil scientists recorded the characteristics of the profiles they studied and compared those profiles with others in nearby counties and in more distant places. They classified and named the soils according to nationwide uniform procedures. They drew the boundaries of the soils on aerial photographs. These photographs show trees, buildings, fields, roads, and other details that help in drawing boundaries accurately. The soil maps at the back of this publication were prepared from aerial photographs.

The areas shown on a soil map are called map units. Most map units are made up of one kind of soil. Some are made up of two or more kinds. The map units in this survey area are described under "General soil map units" and "Detailed soil map units."

While a soil survey is in progress, samples of some soils are taken for laboratory measurements and for engineering tests. All soils are field tested to determine their characteristics. Interpretations of those characteristics may be modified during the survey. Data are assembled from other sources, such as test results, records, field experience, and state and local specialists. For example, data on crop yields under defined management are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it can be used by farmers, woodland managers, engineers, planners, developers and builders, home buyers, and others.

general soil map units

The general soil map at the back of this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit, or soil association, on the general soil map is a unique natural landscape. Typically, a soil association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in other associations but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one soil association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

soil descriptions

1. Primghar-Marcus-Galva association

Level to gently sloping, somewhat poorly drained, poorly drained, and well drained silty soils that formed in loess; on uplands

The soils in this association are on uplands on broad drainage divides and in drainageways (fig. 1). In much of the association, the drainageways are poorly defined, and there are crossable depressions that are ponded in places. Except for Mill Creek there are no permanent streams.

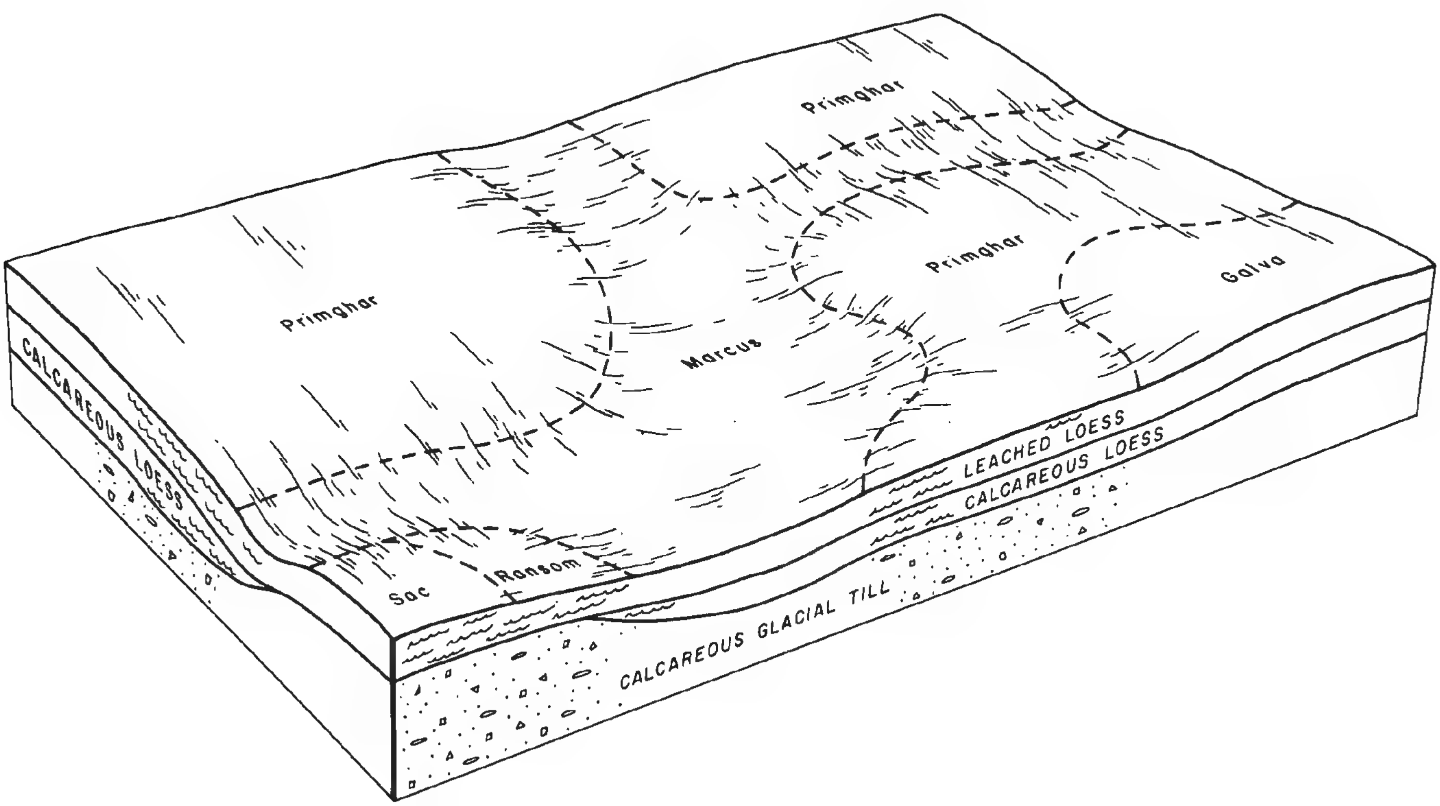

Figure 1.—Typical pattern of soils and parent material in the Primghar-Marcus-Galva association.

This association makes up about 26 percent of the county. Primghar soils make up about 48 percent of the association, Marcus soils make up 30 percent, Galva soils make up 11 percent, and soils of minor extent make up 11 percent.

Primghar soils are level to gently sloping and somewhat poorly drained. They are on plane and convex drainage divides, in small drainageways, and on concave lower side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silty clay loam or silt loam in the lower part. The underlying material is glacial till that is calcareous gravelly loam and clay loam.

Marcus soils are level and poorly drained. They are on uplands in smooth areas and in drainageways. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silty clay loam or silt loam in the lower part. The underlying loess is calcareous silt loam.

Galva soils are level to gently sloping and are well drained. They are on ridgetops and on side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam in the lower part. The underlying loess is calcareous silt loam.

The most extensive minor soils in this association are the Afton, Calco, Ransom, and Sac soils. The poorly drained Afton soils are in upland drainageways. The poorly drained Calco soils are in the lower part of the upland drainageways and in stream bottom lands. The somewhat poorly drained Ransom soils and the well drained Sac soils are on plane to convex upland ridgetops and side slopes.

The soils in this association are suited to row crops and are used mainly for row crops. The main hazards are erosion on the gently sloping soils and soil blowing on soils that are plowed in the fall. These hazards can be reduced by tillage that leaves crop residue on the surface. Crop residue also helps retain soil moisture.

Corn and soybeans are the major crops and are the only crops grown on some cash-grain farms. On many farms with livestock, oats and alfalfa are also grown. Some farms have a small acreage in permanent pasture.

Raising and feeding hogs and feeding cattle are the most common livestock enterprises, but there are also some dairy farms. Some dairy farmers buy alfalfa hay, but most produce their own forage and concentrates, which are fed to livestock.

Contamination of surface and subsurface water by livestock wastes from feedlots is a hazard, mainly because some farms do not have sizable areas of soils that are suitable for livestock waste disposal systems.

The roads in this association follow section lines. Almost all roads are either paved or gravelled.

2. Galva-Primghar association

Level to gently sloping, well drained and somewhat poorly drained silty soils that formed in loess; on uplands

The soils in this association are on broad ridges and on uplands in small drainageways (fig. 2). Some of the ridges are as much as one-half mile long. This association is moderately dissected by drainageways and small streams.

This association makes up about 34 percent of the county. Galva soils make up about 59 percent of the association, Primghar soils make up 14 percent, and soils of minor extent make up 27 percent.

Galva soils are level to gently sloping and are well drained. They are on ridges and side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam in the lower part. The underlying loess is calcareous silt loam.

Primghar soils are level to gently sloping and are somewhat poorly drained. They are on plane and slightly convex drainage divides, in small drainageways, and on concave lower side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silty clay loam or silt loam in the lower part. The underlying glacial till is calcareous loam and clay loam.

The most extensive minor soils in this association are the Afton, Calco, Colo, Marcus, and Sac soils. The poorly drained Afton and Marcus soils are in upland drainageways. The poorly drained Calco and Colo soils are in the larger drainageways and small bottom lands. The well drained Sac soils are on upland ridges and side slopes.

The soils in this association are suited to row crops and are used for row crops. Erosion is a hazard on the sloping soils. Soil blowing is a hazard, especially on soils plowed in the fall. These hazards can be reduced by a tillage system that leaves crop residue on the surface. The crop residue also helps retain soil moisture.

Corn and soybeans are the major crops, but alfalfa and oats are also grown. Many farms have a small acreage in permanent pasture.

Raising and feeding hogs and feeding cattle, and to a lesser extent, dairying are the major livestock enterprises. The soils in this association are suited to livestock waste disposal systems that are properly located, designed, and operated. The well drained soils in areas that are not near streams or large drainageways can be used for large waste disposal systems.

There are roads on nearly every section line in this association. Almost all the roads are paved or gravelled.

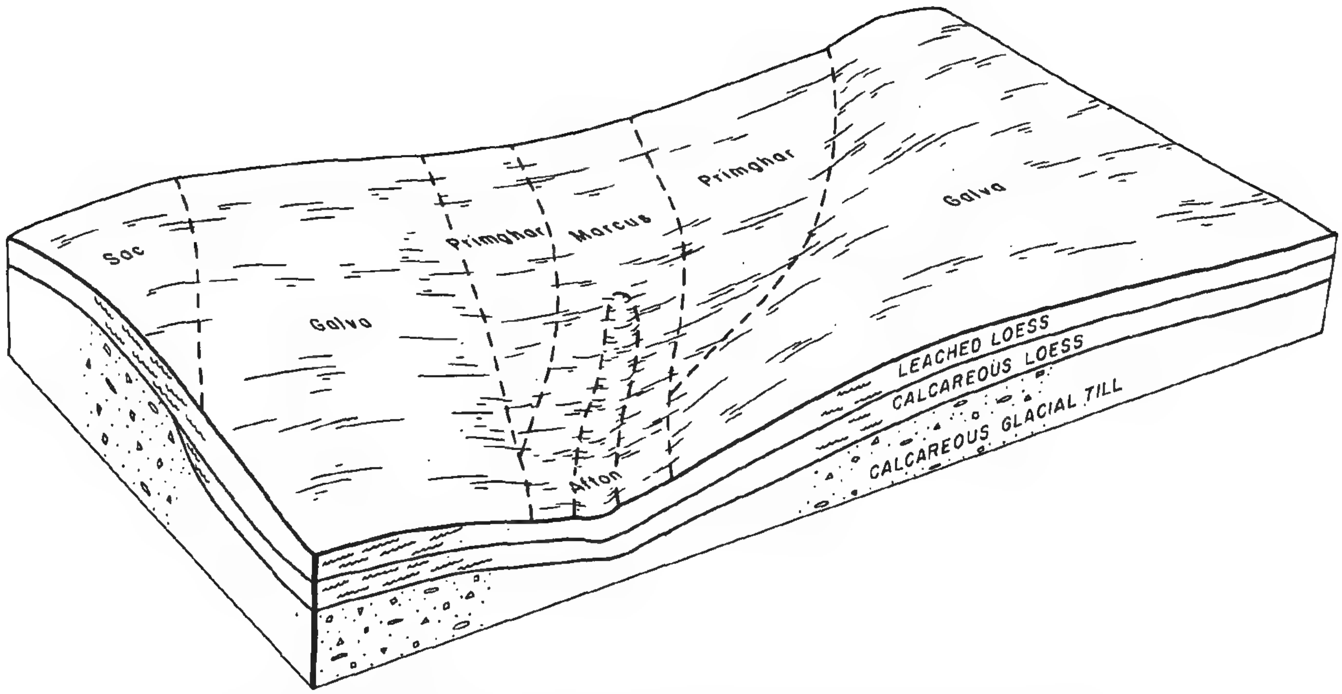

Figure 2.—Typical pattern of soils and parent material in the Galva-Primghar association.

3. Sac-Galva-Primghar association

Level to moderately sloping, well drained and somewhat poorly drained silty soils that formed in loess and the underlying glacial till; on uplands

The soils in this association formed in loess. Sac soils, however, in part formed in glacial till. The soils in this association are on broad ridges, side slopes, and upland drains (fig. 3). They are dissected by drainageways and small streams.

This association makes up about 29 percent of the county. Sac soils make up about 32 percent of the association, Galva soils make up 30 percent, Primghar soils make up 24 percent, and soils of minor extent make up 14 percent.

Sac soils are gently sloping and moderately sloping and are well drained. They are on ridges and side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam, loam, or clay loam in the lower part. The underlying material is glacial till that is calcareous clay loam or loam.

Galva soils are level to gently sloping and are well drained. They are on ridges and side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam in the lower part. The underlying loess is calcareous silt loam.

Primghar soils are level to gently sloping and somewhat poorly drained. They are on plane and convex drainage divides, in small drainageways, on slopes adjacent to drainageways, and on concave lower side slopes. They have a surface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silty clay loam or silt loam in the lower part. The underlying material is glacial till that is calcareous clay loam and loam.

The most extensive minor soils in this association are the Afton, Calco, Colo, Marcus, and Ransom soils. The poorly drained Afton and Marcus soils are in upland drainageways. The poorly drained Calco and Colo soils are in the larger drainageways and on stream bottom lands. The somewhat poorly drained Ransom soils are on uplands on plane and slightly convex slopes.

The soils in this association are suited to row crops and are used mainly for row crops. Erosion is a hazard on the sloping soils. Soil blowing is a hazard, especially on soils plowed in the fall. These hazards can be reduced by tillage that leaves crop residue on the surface. The crop residue also helps retain soil moisture.

Corn and soybeans are the major crops, but alfalfa

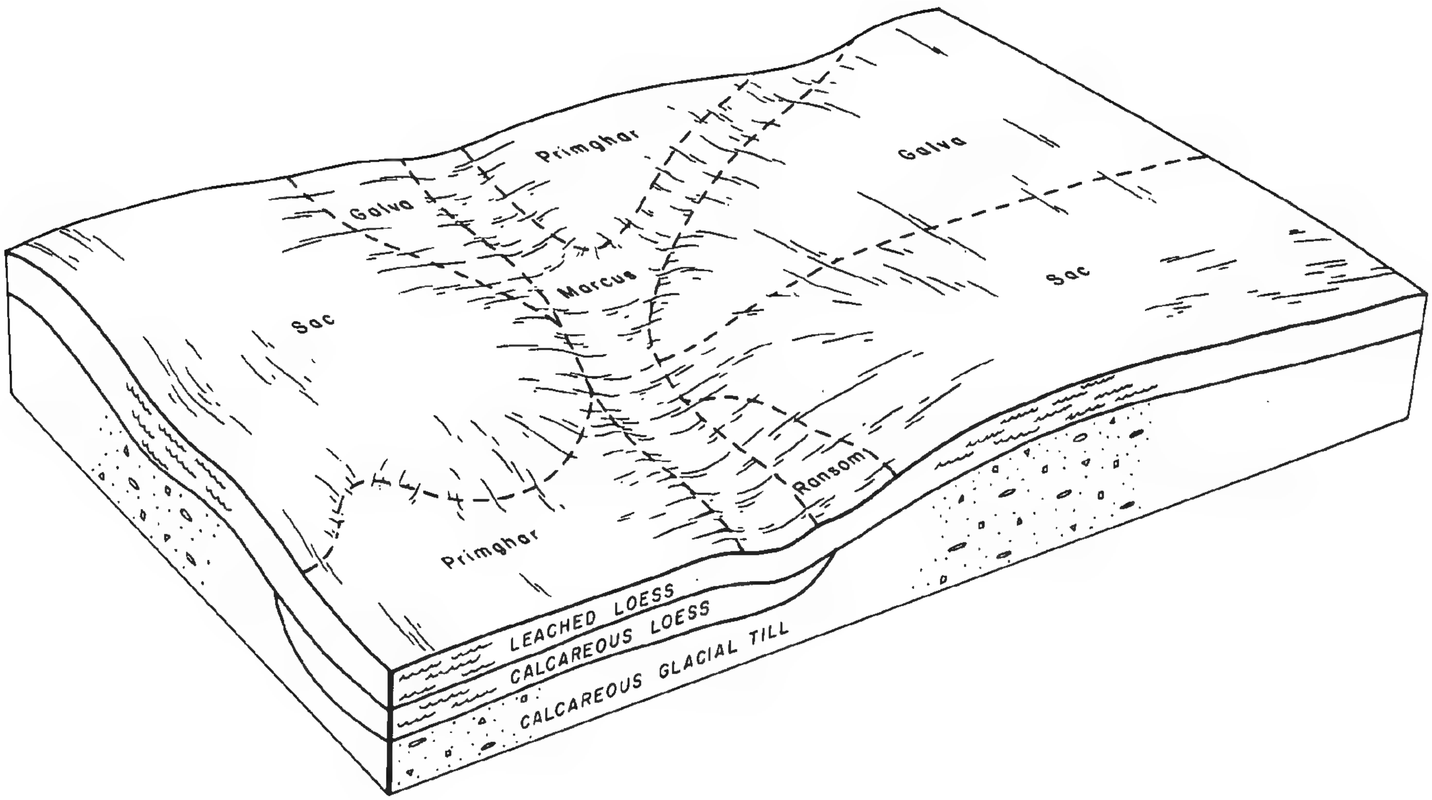

Figure 3.—Typical pattern of soils and parent material in the Sac-Galva-Primghar association.

and oats are also grown. Many farms have a small acreage in permanent pasture.

Raising and feeding hogs and feeding cattle are the most common livestock enterprises. There are also some dairy farms.

Contamination of surface and subsurface water by livestock wastes from high density livestock enterprises is a hazard, but on most farms, soils in sizable areas are suited to livestock waste disposal facilities.

The roads in this association follow section lines. Almost all the roads are gravelled or paved.

4. Calco-Colo-Galva association

Level to gently sloping, poorly drained and well drained silty soils that formed in loess and alluvium; on bottom lands and stream benches

The soils in this association formed in alluvium on bottom lands and in loess on stream benches (fig. 4). The areas parallel major streams in the county and range from one-fourth mile to 1 mile in width. They are dissected by meandering stream channels of variable depth.

This association makes up about 8 percent of the county. Calco soils make up about 19 percent of the association, Colo soils make up 18 percent, Galva soils make up 16 percent, and soils of minor extent make up 47 percent.

Calco soils are level and poorly drained. They are on bottom lands. The surface layer, subsurface layer, and substratum are calcareous silty clay loam.

Colo soils are level and poorly drained. They are on bottom lands. The surface layer, subsurface layer, and substratum are silty clay loam.

Galva soils are level to gently sloping and well drained. They are on stream benches. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam in the lower part. The underlying material is calcareous silt loam loess and alluvial sand and gravel.

The most extensive minor soils in this association are the Estherville, Fairhaven, Spillco, Spillville, and Terril soils. The moderately well drained Terril soils are on alluvial fans and lower side slopes adjacent to bottom lands. The somewhat excessively drained Estherville soils and the well drained Fairhaven soils are on stream benches. The somewhat poorly drained Spillco and Spillville soils are on bottom lands.

The soils on stream benches are used mainly for row crops. The soils on bottom lands are also used for row crops provided that the soils are adequately drained and

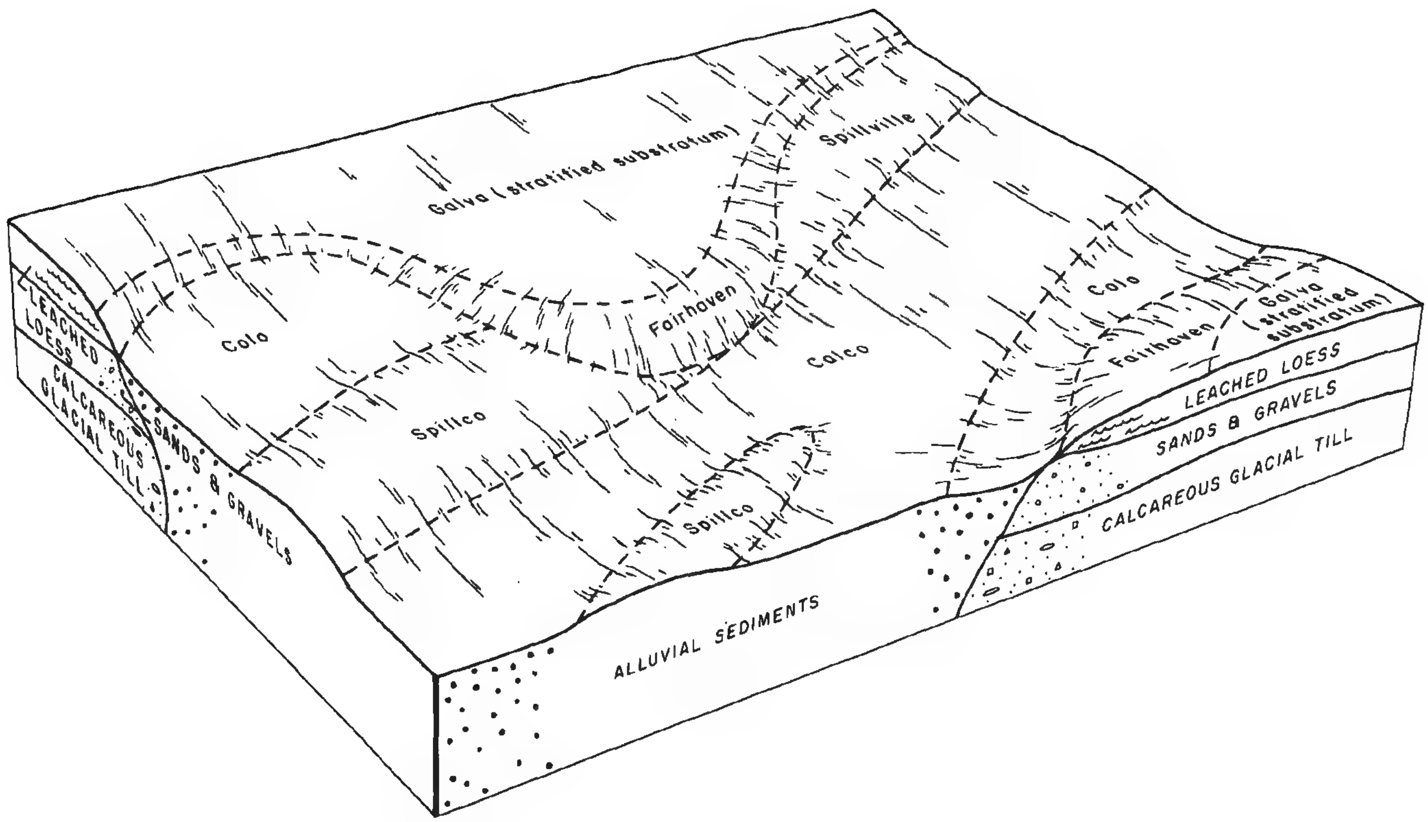

Figure 4.—Typical pattern of soils and parent material in the Calco-Colo-Galva association.

are not frequently flooded and that the areas are large enough for efficient row cropping. In other places the soils are used for pasture.

Soil blowing is a hazard if the soils in this association are plowed in the fall. Soil blowing can be reduced by tillage that leaves crop residue on the soil surface. The crop residue also helps retain soil moisture.

Corn and soybeans are the major crops. Oats and alfalfa are also grown on some farms. Drainage by tile or open ditches improves crop production on the soils on bottom lands.

The soils in some areas are in permanent pasture. There are deposits of sand and gravel on stream benches and in some bottom lands.

The sand and gravel in some places is suitable for commercial use. Some areas have been mined.

The roads in this association follow section lines. Almost all the roads are paved or gravelled.

5. Storden-Galva-Sac association

Level to very steep, well drained silty and loamy soils that formed in loess and glacial till; on uplands

The soils in this association are on ridges and side slopes (fig. 5). They are dissected by shallow drainageways.

This association makes up about 3 percent of the county. Storden soils make up about 36 percent of the association, Galva soils make up 33 percent, Sac soils make up 12 percent, and soils of minor extent make up 19 percent.

Storden soils formed in glacial till on convex side slopes. They have a surface layer of calcareous loam. The substratum is calcareous clay loam glacial till.

Galva soils formed in loess on convex ridges and side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam in the lower part. The underlying material is loess that is calcareous silt loam.

Sac soils formed in loess and in the underlying glacial till. They are gently sloping and moderately sloping soils on ridgetops and side slopes. They have a surface layer and a subsurface layer of silty clay loam. The subsoil is silty clay loam in the upper part and silt loam, loam, or clay loam in the lower part. The underlying material is glacial till that is calcareous clay loam or loam.

The most extensive minor soils in this association are the Calco, Colo, Marcus, Primghar, Salida, Spillco, Spillville, and Terril soils. The poorly drained Marcus soils and the somewhat poorly drained Primghar soils are in uplands in drainageways. The moderately well

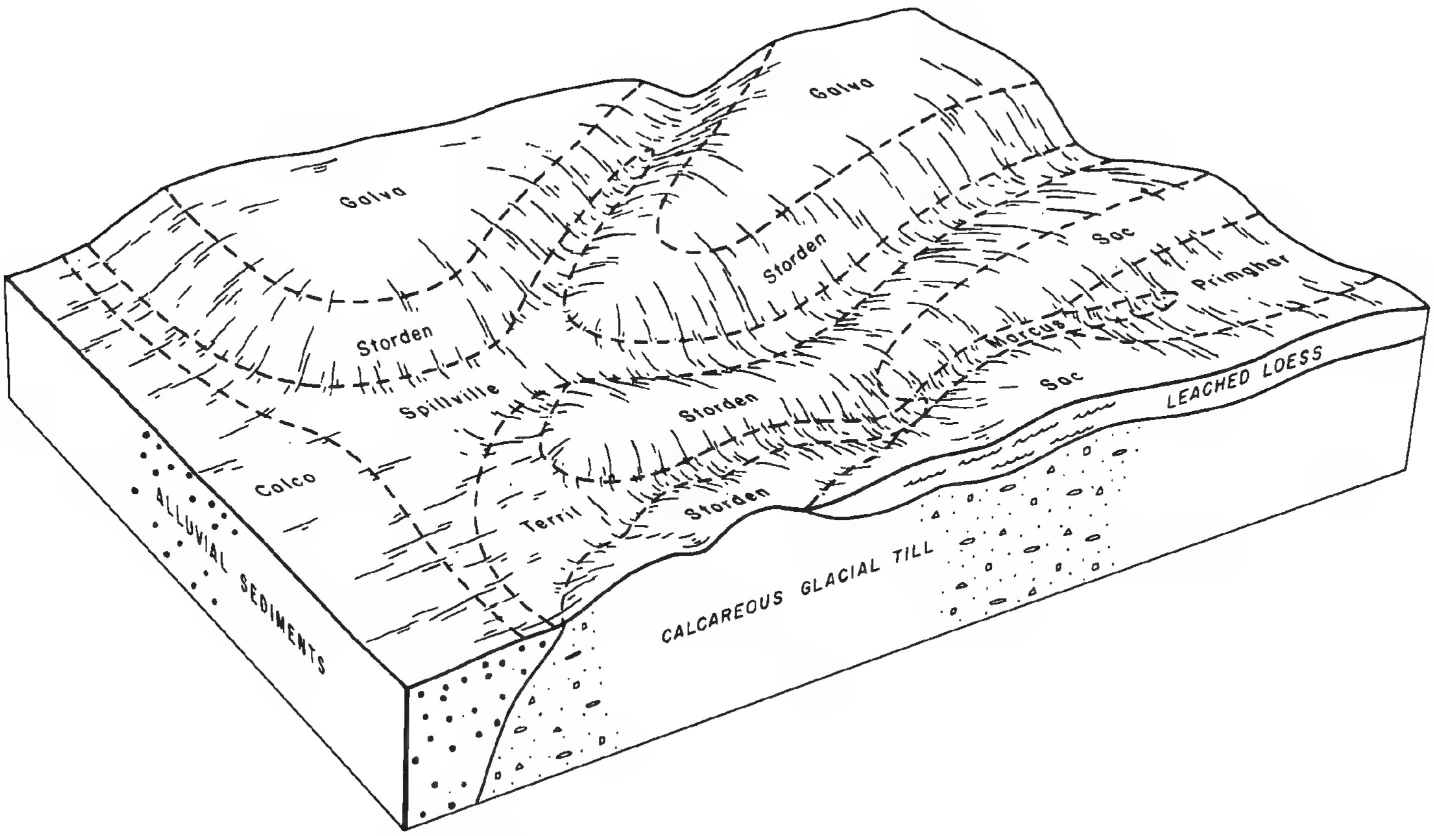

Figure 5.—Typical pattern of soils and parent material in the Storden-Galva-Sac association.

drained Terril soils are on alluvial fans and on foot slopes. The excessively drained Salida soils are on upland ridgetops and on side slopes. The poorly drained Calco and Colo soils and the somewhat poorly drained Spillco and Spillville soils are on bottom lands along small streams.

The level to moderately sloping soils that make up this association are suited to row crops and are used for row crops. Erosion control practices are needed on the sloping soils. The moderately steep to very steep soils are used mainly for permanent pasture. Grazing management and control of undesirable species are major concerns on those soils.

The soils in this association are well suited to diversified crop-livestock farming. Corn and soybeans are grown on the level to moderately sloping soils, and cattle are grazed on the strongly sloping to very steep soils.

Many of the deposits of sand and gravel are in this association, mainly on the strongly sloping to very steep soils on uplands. In places the sand and gravel are of high quality and are suitable for commercial use.

The soils in a large part of this association will continue to be used for permanent pasture. There could be considerable benefit from improved pasture management programs. On the strongly sloping to very steep soils where trees are the dominant vegetation, tree management programs could provide long term benefits. Some of the most scenic areas in the county are in the areas of this association. Some of these areas have potential for use as sites for houses and for recreation development.

Roads are generally adequate. Most of the roads are gravelled. Some roads follow section lines, and others follow ridgetops or the lower slopes of hillsides.

broad land use considerations

The soils in O'Brien County vary widely in their potential for major land uses. The potential of the soils reflects the relative cost of common management practices and the limitations imposed by soil related problems that remain after the practices are installed.

Approximately 86 percent of the land in the county is used for cultivated crops, mainly corn and soybeans. Cropland is the dominant use of the soils in all the associations except those in association 5. Some of the

soils in association 4 are flooded, generally in spring. The flooding causes slight to moderate crop damage and delays preparation of the seedbed and planting. On soils in a few parts of association 1, crops are damaged because the drainage system does not remove excess water rapidly enough. Wetness is the main limitation for crops on the soils in associations 1 and 4, particularly on the Calco, Colo, and Marcus soils. On the sloping soils in associations 2, 3, and 5, erosion is a hazard. On the soils in all the associations, soil blowing is a hazard, especially late in winter, if the surface is not protected by crop residue.

Approximately 8 percent of the land in the county is used for pasture. In all the associations, the potential is good for grasses and legumes. Pastureland is most extensive on soils in association 5 and, to a lesser extent, on those in association 4. The main soils in associations 4 and 5 that are used for pasture are Calco, Colo, and Storden soils.

An adequate water supply for irrigating cropland and pasture is generally available only in association 4. Some of the soils in this association are underlain by sand and gravel to a depth below the water table. The soils in this association that are on stream terraces have good potential for irrigated crops.

In associations 2, 3, and 5, there are large confined livestock facilities that have a lagoon waste disposal system. Generally, associations 2 and 3 have good potential for waste disposal systems. Association 1 has fair potential because of low relief and a high proportion of poorly drained soils. Associations 4 and 5 have poor potential. In association 4, the poorly drained soils on bottom lands are subject to flooding, and excessive waste leaching is a hazard on soils on stream terraces. In association 5, some of the less sloping soils have good potential for waste disposal systems.

About 2,700 acres in and around the towns in the county are used for building sites, streets, and associated urban uses. The towns are mainly in associations 2 and 3. The well drained Galva and Sac soils in these associations have fair potential for urban uses. The seasonal water table in Primghar soils must be controlled by means of artificial drainage, otherwise those soils are not suitable for most urban uses.

A very small part of the county is used for recreation. In associations 2, 3, and 5, the potential is good for most recreation uses. The Primghar soils in associations 2 and 3 have only fair potential for some intensive recreation uses, such as playgrounds and camp areas, because they remain wet longer than the other soils in associations 2 and 3. The steep and very steep Storden soils are not suited to uses such as golf fairways, campsites,and playgrounds. In general, the soils in associations 1 and 4 have poor potential for most recreation uses because some of the soils are poorly drained. Furthermore, some of the soils in association 4 are subject to flooding. In associations 1 and 4, however, the soils in some small areas are suitable for intensive recreation development.

The potential for wildlife habitat is good throughout the county. The soils in associations 1, 2, 3, and 4 have good potential for development of habitat for openland wildlife. The soils in associations 4 and 5 have good potential for development of habitat for pastureland and woodland wildlife. The soils on bottom lands in association 4 have good potential for development of habitat for wetland wildlife.

detailed soil map units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and management of the soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Galva silty clay loam, 2 to 5 percent slopes, is one of several phases in the Galva series.

Some map units are made up of two or more major soils. These map units are called soil complexes.

A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Storden-Salida complex, 25 to 40 percent slopes is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, gravel is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

The soil maps of O'Brien County join the soil maps of the published Soil Survey of Clay County. Soil names differ in a few places because of refinements in mapping some of the soil series in O'Brien County.

soil descriptions

26—Kennebec silty clay loam, 0 to 2 percent slopes. This is a level, moderately well drained soil on bottom lands. It is subject to flooding. Most areas are irregular in shape and range from 5 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black and very dark brown silty clay loam 19 inches thick. The next layer is about 12 inches thick. It is very dark grayish brown silty clay loam in the upper part and dark brown silt loam in the lower part. The underlying material is brown and dark grayish brown silt loam.

Included in mapping are soils that are calcareous in the surface layer. These soils do not occur in a consistent pattern; they make up about 5 percent of the map unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is very high. The surface layer is about 5 or 6 percent organic matter. It generally is neutral or slightly acid. The available phosphorus and available potassium in the subsurface layer are low. A seasonal high water table is at a depth of 3 to 5 feet.

In most areas, this soil is cultivated. It is well suited to corn, soybeans, small grain, and grasses and legumes for hay and pasture if flooding is controlled. Good tilth is easily maintained.

In a few areas, the soil is used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability class is I.

27B—Terril loam, 2 to 5 percent slopes. This is a gently sloping, moderately well drained soil on foot slopes and alluvial fans. Slopes are slightly concave to slightly convex. Most of the areas on foot slopes are narrow bands that are one-eighth to three-eighths mile long and 150 to 450 feet wide. Most individual areas range from 2 to 15 acres in size.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam 27 inches thick. The subsoil is friable and is about 18 inches thick. It is very dark grayish brown clay loam in the upper part, dark brown and brown clay loam in the middle part, and brown and yellowish brown clay loam in the lower part. The underlying material is olive brown loam. In places this soil is silty clay loam. In a few small areas this soil has a surface layer that is less than 24 inches thick.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 4 or 5 percent organic matter. It generally is slightly acid or neutral. The available phosphorus and available potassium in the lower part of the subsurface layer are very low.

In some areas, this soil is cultivated. It is well suited to corn, soybeans, and small grains, but many narrow areas are adjacent to soils that are used for pasture and cannot be managed separately. This soil is well suited to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, erosion and sedimentation are hazards unless the soil is protected from the runoff from soils higher on the slope. Terraces or a diversion on the slopes above this soil could control the runoff. Conservation tillage and contouring also reduce these hazards. Good tilth is easily maintained.

In some areas, this soil is used for hay and pasture. Grasses and legumes protect the soil from erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

In a few areas the soil remains in native hardwood trees. Grazing should be controlled in those areas.

The capability subclass is IIe.

27C—Terril loam, 5 to 14 percent slopes. This is a moderately and strongly sloping, moderately well drained soil on foot slopes and alluvial fans. Slopes range from slightly concave to slightly convex. Most areas on foot slopes are narrow bands that range from one-eighth to three-eighths mile in length and from 150 to 350 feet in width. Most areas range from about 2 to 10 acres in size.

Typically, the surface layer and subsurface layer are loam about 32 inches thick. The surface layer is black and the subsurface layer is black and very dark brown. The subsoil is friable clay loam about 19 inches thick. It is very dark brown in the upper part and very dark grayish brown and very dark gray in the lower part. The underlying material is olive brown loam. In a few areas this soil is silty clay loam, and in a few other areas the surface layer is less than 24 inches thick.

Included in mapping are soils that are calcareous or have glacial till in the surface layer. Those soils are in the more convex positions and make up about 5 percent of the map unit. Also included are soils that generally are droughty because they are underlain by sandy or gravelly layers. Those soils do not occur in a consistent pattern; they make up about 2 percent of the unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 4 or 5 percent organic matter. Generally it is slightly acid or neutral. The available phosphorus and available potassium in the lower part of the surface layer are very low.

Most areas of this soil are in pasture because they are narrow bands adjacent to pastureland. A few areas are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. If the soil is used for cultivated crops, overflow, erosion, and sedimentation are hazards unless the soil is protected from the runoff from soils higher on the slope. These hazards can be reduced by conservation tillage and contouring. Runoff can be controlled by terraces or a diversion on this soil and on the slopes above this soil. Good tilth is easily maintained.

Grasses and legumes for hay and pasture protect this soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

A few areas remain in native hardwoods. Grazing in those areas should be controlled.

This soil is in capability subclass IIIe.

31—Afton silty clay loam, 0 to 2 percent slopes. This is a level, poorly drained soil in concave drainageways on uplands. It is subject to frequent, very brief flooding. Most areas are narrow bands that range from one-fourth mile to 2 miles in length and from 125 to 350 feet in width. Most areas range from about 3 to 60 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay loam 19 inches thick. The subsoil is friable and is about 25 inches thick. It is olive gray silty clay loam and has yellowish brown and light olive brown mottles. The underlying material is olive gray silt loam. In a few areas this soil has 6 to 15 inches of calcareous overwash on the surface.

Included in mapping are small areas of soils that are gravelly in the surface layer or are calcareous higher in the profile. Also included are small areas of soils that are underlain by sandy or gravelly material. These included areas do not occur in a consistent pattern.

Permeability is moderately slow. Surface runoff is slow. The available water capacity is very high. The surface layer is about 6 or 7 percent organic matter. It generally is neutral or mildly alkaline. In the subsoil, the available

phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 1 to 3 feet.

In most of the wider areas where drainageways are improved, this soil is cultivated. It is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If tile drainage is not adequate, cultivated crops are subject to damage by excess water. Runoff from adjacent soils that are higher on the landscape results in crop damage from overflow and siltation. Terraces, contouring, and grassed waterways on the slopes above this soil reduce overflow and siltation on this soil and extend the periods between cleaning out drainage ditches. Conservation tillage also reduces these hazards. Timely field operations are important in maintaining good tilth.

In many narrow or unimproved areas, this soil is used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIw.

32—Spicer silty clay loam, 0 to 2 percent slopes. This is a level, poorly drained calcareous soil in concave drainageways and plane areas on uplands. Most areas are longer than they are wide and range from 5 to 40 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black and very dark gray silty clay loam about 12 inches thick. The subsoil is friable and is about 19 inches thick. In the upper part it is dark gray and very dark gray silty clay loam with grayish brown, light olive brown, and strong brown mottles. In the lower part it is olive gray silty clay loam with brownish yellow, strong brown, and gray mottles. The underlying material is mainly gray silt loam. In a few areas this soil is dark in color to a depth of 2 to 3 feet, and in a few areas it does not have excess lime in part of the subsoil.

Included in mapping are small areas of Marcus soils. These soils do not occur in a consistent pattern; they make up about 10 percent of the map unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is very high. The surface layer is about 6 or 7 percent organic matter. It is mildly or moderately alkaline. In the subsoil, the available phosphorus and available potassium are very low. The plow layer and subsoil are calcareous. A seasonal high water table is at a depth of 1 to 3 feet.

In most areas, this soil is cultivated. It is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage by wetness if tile drainage is not adequate. In concave drainageways on uplands, crops are damaged by overflow and siltation from runoff from adjacent soils higher on the landscape. Terraces, contouring, and grassed waterways on slopes above this soil reduce overflow and siltation on this soil. Conservation tillage also reduces these hazards. Timely field operations are important in maintaining good tilth. Soybean varieties selected for this soil must be able to tolerate excess lime, and pesticides must be effective under the excess lime conditions.

In a few areas, this soil is used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIw.

72B—Estherville loam, 1 to 4 percent slopes. This is a gently sloping, somewhat excessively drained soil on stream benches about 3 to 10 feet above the adjacent bottom lands. Most areas are irregular in shape and range from 2 to 8 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is about 11 inches thick. It is very dark gray loam in the upper part and very dark grayish brown and dark brown sandy loam in the lower part. The underlying material is yellowish brown and light yellowish brown gravelly coarse loamy sand. It is 40 to 70 percent gravel. In some of the more convex areas, the surface layer is less than 7 inches thick or is lighter colored.

Included in mapping are soils that have sand and gravel at a depth of 16 to 20 inches. These soils make up about 10 percent of the map unit. Also included are small areas of soils that have gravel, stones, or cobbles in the surface layer. These soils make up about 5 percent of the unit. Some of the included soils are more convex than the Estherville soil, and others are in plane or concave areas near the lower edge of the Estherville soil adjacent to bottom lands.

Permeability is moderately rapid. Surface runoff is medium. The available water capacity is low. The surface layer is about 2 or 3 percent organic matter. It generally is neutral to medium acid depending on past liming practices. In the subsoil the available phosphorus and available potassium are very low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops grown on this soil are often damaged by drought unless summer rainfall is above average. Erosion is a hazard on the longer slopes or where runoff from other soils crosses this soil. Conservation tillage and contouring are effective in reducing erosion. Good tilth is easily maintained. Terraces generally are not constructed on this soil if erosion can be controlled by other means. Terrace channel cuts will expose coarse textured unproductive material in most places. Plant root development is restricted by layers of sand or gravel at a depth of 20 to 30 inches.

A few areas are used for hay and pasture. Grasses and legumes protect this soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during dry periods help to keep the soil and pasture in good condition.

The capability subclass is IIs.

72D—Estherville loam, 5 to 14 percent slopes. This is a moderately and strongly sloping, somewhat excessively drained soil mainly on the edge of stream benches about 3 to 10 feet above the adjacent bottom lands. The areas are generally longer than they are wide and range from 2 to 12 acres in size.

Typically, the surface layer is very dark grayish brown loam about 6 inches thick. The subsurface layer is dark brown loam about 3 inches thick. The subsoil is about 19 inches thick. It is friable, brown loam in the upper part; friable, brown and yellowish brown sandy loam in the middle part; and very friable, yellowish brown loamy sand in the lower part. The underlying material is light yellowish brown and pale brown gravelly sand and sand. At the lower part of the slope in most areas of this soil, the surface layer is more than 9 inches thick. In a few small areas the surface layer is silty clay loam.

Permeability is moderately rapid. Surface runoff is medium or rapid. The available water capacity is low. The surface layer is about 2 or 3 percent organic matter. It generally is neutral to medium acid depending on past liming practices. In the subsoil the available phosphorus and available potassium are very low.

Some areas of this soil are cultivated. This soil is poorly suited to corn, soybeans, and small grains. It is suited to grasses and legumes for hay and pasture. Crops are often damaged by drought unless summer rainfall is above average. Erosion is a hazard. Conservation tillage and contouring reduce erosion. In some places contouring cannot be used because of short uneven slopes. Good tilth is easily maintained. Terraces generally are not constructed on this soil if erosion can be controlled by other means. Terrace channel cuts will expose coarse textured unproductive material in most places. Plant root development is restricted by layers of sand or gravel at a depth of about 20 to 30 inches.

Some areas of this soil are used for hay and pasture. Grasses and legumes protect this soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during dry periods help to keep the soil and pasture in good condition.

The capability subclass is IVs.

73E—Salida sandy loam, 9 to 18 percent slopes. This is a strongly sloping and moderately steep, excessively drained calcareous soil on short side slopes adjacent to streams and on the edge of stream benches. The areas generally are longer than they are wide and range from 2 to 10 acres in size.

Typically, the surface layer is about 6 inches thick. It is very dark brown sandy loam that is about 10 percent gravel. The subsurface layer is very dark grayish brown, loose gravelly sandy loam about 3 inches thick. The subsoil is brown, loose gravelly loamy sand about 3 inches thick. The underlying material is stratified gravelly loamy sand and gravelly sand that is yellowish brown, brown, and strong brown. In most areas, the thickness of the surface layer increases from the upper part of the slope to the lower part. The surface layer is 12 to 18 inches thick in the lower part of the slopes in most areas.

Included in mapping are areas of less than 2 acres that have been borrowed, exposing the gravelly underlying material. These areas make up about 10 percent of the map unit. Also included are well drained Storden soils. They make up about 5 percent of the unit and do not occur in a consistent pattern.

Permeability is very rapid. Surface runoff is slow. The available water capacity is very low. The surface layer is about 0.5 or 1 percent organic matter. It is neutral to moderately alkaline. In the subsoil, the available phosphorus and available potassium are very low.

This soil is used mainly for pasture. It is generally not suited to corn, soybeans, and small grains. Cultivated crops are damaged by drought unless summer rainfall is well above average, and most tillage is impractical because of rocks in the surface layer. The soil is poorly suited to grasses and legumes for hay and pasture. A good distribution of rainfall is needed to grow grasses and legumes. A plant cover reduces erosion and soil blowing and maintains good tilth. If plant growth is reduced by low soil moisture, the pasture can be maintained by proper stocking rates and deferred grazing.

The capability subclass is VIe.

73F—Salida sandy loam, 18 to 40 percent slopes. This is a steep and very steep, excessively drained calcareous soil on upland ridgetops and upper side slopes, on lower side slopes adjacent to streams, and on the edge of stream benches. The areas are longer than they are wide, except on the upper side slopes where they are irregular in shape. Most areas range from 2 to 10 acres in size.

Typically, the surface layer is about 9 inches thick. It is black and very dark gray sandy loam that is about 15 percent gravel. The subsoil is about 3 inches thick. It is brown, loose gravelly loamy sand. The underlying material is yellowish brown and light yellowish brown sand and gravel.

Included in mapping are soils with a texture of stratified loam and sandy loam. These soils do not have gravel in the surface layer and subsoil. They make up about 10 percent of the map unit. Also included are borrow areas where the gravelly underlying material has been exposed. These areas are in an irregular pattern and are less than 2 acres in size. They make up about 5 percent of the unit.

Permeability is very rapid. Surface runoff is slow. The available water capacity is very low. The surface layer is 0.5 or 1 percent organic matter. It generally is neutral to moderately alkaline. The available phosphorus and available potassium in the subsoil are very low.

Most areas of this soil are used for pasture. This soil is very poorly suited to corn, soybeans, and small grains. It is too steeply sloping in many places for conventional tillage and is too gravelly and too droughty for row crops. This soil is poorly suited to grasses and legumes for pasture. Pasture production needs a good distribution of rainfall. A plant cover reduces erosion and soil blowing and maintains good tilth. If plant growth is reduced by low soil moisture, the pasture can be maintained by proper stocking rates and deferred grazing.

This soil is in capability subclass VIIe.

77B—Sac silty clay loam, 2 to 5 percent slopes. This is a gently sloping, well drained soil on convex upland ridgetops and side slopes. Most areas are irregular in shape and range from 10 to 50 acres in size.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsurface layer is dark brown and very dark brown silty clay loam about 5 inches thick. The subsoil is friable and is about 24 inches thick. It is brown silty clay loam in the upper part, yellowish brown silty clay loam and silt loam in the middle part, and yellowish brown loam in the lower part. The underlying material is light olive brown clay loam. On some convex ridgetops the surface layer is thinner and lighter colored than is typical.

Included in mapping are small areas of soils that have glacial till or gravelly material in the surface layer. Those soils are in some of the more convex positions. Also included are areas of soils that generally are droughty because they are underlain by sandy or gravelly material. Most of those soils are adjacent to stream bottom lands, but some are in high positions on uplands. Their pattern is not consistent.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter. It is medium acid to neutral, depending on past liming practices. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion, especially those on the longer slopes. Conservation tillage, contouring, and terracing (fig. 6) reduce érosion. Terrace channel cuts expose loam or clay loam glacial till in places. Good tilth is easily maintained.

A few areas are used for hay and pasture. Grasses and legumes protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIe.

77C2—Sac silty clay loam, 5 to 9 percent slopes, moderately eroded. This is a moderately sloping, well drained soil commonly on the lower part of side slopes.

Figure 6.—Tile outlet terraces are used to control erosion on this field of corn. The soil is Sac silty clay loam, 2 to 5 percent slopes.

Most areas are irregular in shape and range from 5 to 25 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick. The subsoil is friable and is about 25 inches thick. It is brown and dark yellowish brown silty clay loam in the upper part, yellowish brown silty clay loam in the middle part, and yellowish brown loam with gray and brownish yellow mottles in the lower part. The underlying material is mainly brownish yellow clay loam. Where this soil has not been cultivated (about 25 percent of the area), the surface layer is very dark gray silty clay loam that is about 12 inches thick, and the subsoil is darker colored in the upper part than the subsoil in cultivated areas.

Included in mapping are small areas of soils that have glacial till or gravelly material in the surface layer. Those soils are in the more convex positions. Also included are small areas of soils that are similar to the Sac soil but generally are droughty because they are underlain by sandy or gravelly layers. Those soils do not occur in a consistent pattern.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 2 or 3 percent organic matter. The surface layer and the upper part of the subsoil are medium acid to neutral, depending on past liming practices. In the subsoil, the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. Cultivated areas are subject to erosion. Conservation tillage reduces erosion. Contouring and terracing are effective in reducing erosion but cannot be used where slopes are short. Terrace channel cuts expose loam or clay loam glacial till in places. Good tilth is easily maintained.

A few areas of this soil are used for hay and pasture. Grasses and legumes protect this soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

89B—Sac Variant silty clay loam, 2 to 5 percent slopes. This is a gently sloping, well drained soil on convex ridgetops on uplands and on some side slopes. Most areas are irregular in shape and range from 2 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is dark brown silty clay loam about 4 inches thick. The subsoil is friable and is about 17 inches thick. In the upper part, it is brown silty clay loam; in the middle part, it is yellowish brown silty clay loam; and in the lower part, it is yellowish brown silt loam and has a few gray mottles. The underlying material is mainly yellowish brown and light brownish gray silt loam. In a few areas this soil has a thin layer of sandy or gravelly material between the glacial drift and loess. On some convex ridgetops the surface layer is thinner and lighter colored than is typical.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter. It is neutral to medium acid, depending on past liming practices. In the subsoil, the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion, especially those on the longer slopes. Conservation tillage, contouring, and terracing reduce erosion. Good tilth is easily maintained.

A few areas are used for hay and pasture. Grasses and legumes protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIe.

89C2—Sac Variant silty clay loam, 5 to 9 percent slopes, moderately eroded. This is a moderately sloping, well drained soil commonly on lower side slopes. Most areas are irregular in shape and range from 2 to 15 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 6 inches thick. The subsoil is friable and is about 23 inches thick. It is brown silty clay loam in the upper part, dark yellowish brown and yellowish brown silty clay loam in the middle part, and yellowish brown clay loam in the lower part. The underlying material is brown silty clay loam and loam. In a few small areas, the subsoil is partly silty clay.

Included in mapping are areas of soils that have glacial drift in the surface layer. These soils are in the more convex positions. They make up about 10 percent of the map unit. Also included are small areas of soils that are similar to the Sac soil but generally are droughty because they are underlain by sandy or gravelly layers. These soils do not occur in a consistent pattern. They make up about 10 percent of the map unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 2 or 3 percent organic matter. It generally is neutral to medium acid, depending on past liming practices. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion. Conservation tillage reduces erosion. Contouring and terracing are also effective in reducing erosion but cannot be used where slopes are short. Good tilth is easily maintained.

A few areas are used for hay and pasture. Grasses and legumes protect this soil from erosion and retard

runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

91—Primghar silty clay loam, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil in broad, plane, and convex areas on uplands. Most areas are irregular in shape and range from about 10 to 100 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is black and very dark brown silty clay loam about 11 inches thick. The subsoil is friable and is about 27 inches thick. It is dark grayish brown silty clay loam in the upper part, olive brown silty clay loam with brown mottles in the middle part, and light olive brown silt loam with grayish brown and brown mottles in the lower part. The underlying material is mainly light olive brown and yellowish brown gravelly loam and clay loam. In some places it is silt loam to a depth of 60 inches.

Included in mapping are small areas of calcareous soils that in places are adjacent to poorly drained calcareous soils and generally are in convex positions. Also included are small areas of soils that generally are droughty because they are underlain by sandy or gravelly layers at a depth of about 3 feet. In some places these soils are adjacent to stream bottom lands, but in other places they do not occur in any definite pattern.

Permeability is moderate. Surface runoff is slow. The available water capacity is very high. The surface layer is about 5 or 6 percent organic matter. Generally it is neutral to medium acid. In the subsoil, the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Conservation tillage helps to maintain good tilth and reduces the hazard of soil blowing.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability class I.

91B—Primghar silty clay loam, 2 to 4 percent slopes. This is a gently sloping, somewhat poorly drained soil in concave drainageways on uplands. Most areas are longer than they are wide and range from 5 to 50 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is about 9 inches thick. It is black in the upper part and very dark gray and very dark grayish brown in the lower part. The subsoil is friable and is about 24 inches thick. In the upper part it is dark grayish brown and brown silty clay loam and has yellowish brown and strong brown mottles. In the lower part it is light olive brown silt loam and has light brownish gray mottles. The underlying material is mainly grayish brown to light olive brown silt loam. In some small areas, sandy or gravelly layers are at a depth of about 3 feet.

Permeability is moderate. Surface runoff is medium. The available water capacity is very high. The surface layer is about 5 or 6 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage by erosion, overflow, and siltation. Terracing and contouring on the higher slopes above this soil reduce overflow and siltation, and grassed waterways reduce erosion. Conservation tillage also reduces these hazards. Good tilth is easily maintained.

A few areas are used for pasture and many are partly used for grassed waterways. Grasses and legumes reduce erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIe.

92—Marcus silty clay loam, 0 to 2 percent slopes. This is a level, poorly drained soil in concave drainageways and plane divides on uplands. Most areas in the concave drainageways are narrow bands that range from one-fourth mile to 2 miles in length and from 3 to 60 acres in size. Most areas in the flat divides are broad irregular areas that range from about 10 to 100 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is about 9 inches thick. It is black silty clay loam in the upper part and very dark gray silty clay loam in the lower part. The subsoil is friable and is about 32 inches thick. In the upper part it is dark gray and olive gray silty clay loam and has reddish yellow and brownish yellow mottles; in the middle part it is gray silty clay loam and has brownish yellow mottles; in the lower part it is mottled light gray and brownish yellow silt loam. The underlying material is light gray and light olive gray silt loam to a depth of about 59 inches and light gray and brownish yellow loam below a depth of 59 inches. In a few places loam or clay loam glacial till is at a depth of 24 to 40 inches.

Included in mapping are small areas of soils that are calcareous in the surface layer. Those soils do not occur in a definite pattern; some are adjacent to drainageways. Also included is a soil that has more clay in the subsoil. One area of this soil is near the southeast corner of

section 27 in Baker Township. Another is near the center of section 17 in Dale Township. The high content of clay reduces the effectiveness of a conventional tile drainage system.

Permeability is moderately slow. Surface runoff is slow. The available water capacity is very high. The surface layer is about 6 or 7 percent organic matter. Generally it is slightly acid to mildly alkaline. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 1 to 3 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If tile drainage is not adequate, crops are subject to damage by wetness (fig. 7). In the concave drainageways, crops may be damaged by overflow and siltation caused by runoff from adjacent soils higher on the landscape. Terraces, contouring, and grassed waterways in areas above this soil reduce overflow and siltation on this soil. Conservation tillage also reduces these hazards. Timely field operations are important in maintaining good tilth.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIw.

133—Colo silty clay loam, 0 to 2 percent slopes. This is a level, poorly drained soil on flood plains of large streams, small stream bottom lands, and on the lower part of upland drainageways. It is subject to flooding. The areas are relatively long and narrow in the upland drainageways and the small bottom lands and are irregular in shape on the flood plains. Most areas range from about 5 to 75 acres in size.

Typically, the surface layer is black silty clay loam about 5 inches thick. The subsurface layer is about 37 inches thick. It is black silty clay loam in the upper part and very dark gray silty clay loam with a few brown mottles in the lower part. The layer below that is about 16 inches thick. It is very dark gray silty clay loam with a few brown mottles. The underlying material is gray and light olive gray silty clay loam. In some areas, calcareous layers are at a depth of 10 to 40 inches.

Included in mapping are small areas of soils that are calcareous in the plow layer. These soils make up about 1 percent of the map unit and do not occur in a definite pattern. Crop varieties that tolerate excess lime are more productive in these areas.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 5 to 7 percent organic matter. Generally it is neutral. The available phosphorus and available potassium in the middle part of the subsurface layer are low. A seasonal high water table is at a depth of 1 to 3 feet.

Most areas of this soil are cultivated, except for long, narrow areas, which generally are pastured (fig. 8). This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are subject to damage by wetness, and in some places, by flooding and siltation. Tile or surface drains are used in places to improve drainage. Timely field operations are important in maintaining good tilth.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing

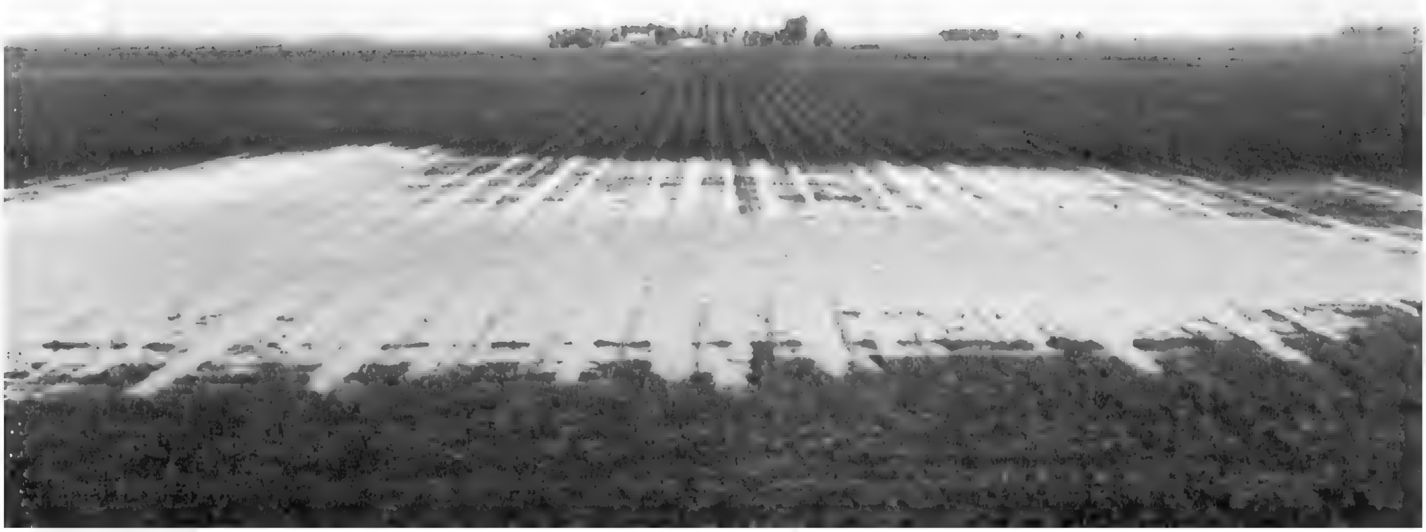

Figure 7.—After heavy rains, water ponds in small depressions on Marcus silty clay loam, 0 to 2 percent slopes. The crop is corn.

Figure 8.—Native grass pasture on Colo silty clay loam, 0 to 2 percent slopes. Meandering stream channels and seasonal flooding make some areas of the Colo soil impractical to cultivate.

during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIw.

202—Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil on stream benches about 2 to 6 feet above the adjacent bottom lands. Most areas are irregular in shape and range from about 5 to 25 acres, but some are as small as 2 acres.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is about 11 inches thick. It is black and very dark gray clay loam in the upper part and very dark gray and dark grayish brown clay loam in the lower part. The subsoil is friable and is about 12 inches thick. It is mainly very dark grayish brown, dark grayish brown, and light olive brown clay loam and loam in the upper part and light olive brown sandy loam with dark grayish brown mottles in the lower part. The underlying material is light olive brown and light yellowish brown sand that is about 20 percent gravel.

Included in mapping are areas of soils that are calcareous. These soils make up about 10 percent of the map unit, and they commonly are near areas of poorly drained calcareous soils. Crop varieties that tolerate excess lime are more productive in these areas.

Permeability is moderate in the upper part and very rapid in the lower part. Surface runoff is slow. The available water capacity is moderate. The surface layer is about 4 or 5 percent organic matter. Generally it is neutral or slightly acid. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are subject to damage by drought. Good tilth is easily maintained. Root growth is restricted by the underlying sand or gravel.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIs.

203—Cylinder silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil on stream benches about 2 to 6 feet above the adjacent bottom lands. Most areas are irregular in shape except along drainageways, where they are long and narrow. Most areas range from about 2 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is about 9 inches thick. It is very dark gray silty clay loam in the upper part and very dark gray and dark grayish brown silty clay loam in the lower part. The subsoil is friable and is about 16 inches thick. It is brown silty clay loam and has light brownish gray, brownish yellow, and reddish yellow mottles. The underlying material is light olive brown gravelly loamy sand. In a few areas the depth to sandy or gravelly material is more than 40 inches.

Included in mapping are small areas of soils that are calcareous in the surface layer. These soils make up about 10 percent of the map unit. They commonly are near areas of poorly drained calcareous soils. Crop varieties that tolerate excess lime are more productive in these areas.

Permeability is moderate in the upper part and very rapid in the lower part. Surface runoff is slow. The available water capacity is moderate. The surface layer is about 4 or 5 percent organic matter. Generally it is neutral or slightly acid. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Good tilth is easily maintained. Root growth is restricted by the underlying sand or gravel, and crops are susceptible to damage by drought unless rainfall is timely.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability class I.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This is a level, poorly drained soil on stream benches about 1 to 4 feet above the adjacent bottom lands. Most areas in the small stream valleys are long and narrow; in the wider valleys of major streams they are irregular in shape. Most areas range from 5 to 40 acres in size.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is black and very dark gray silty clay loam about 11 inches thick. The subsoil is friable and is about 19 inches thick. It is dark grayish brown and very dark grayish brown mottled clay loam in the upper part and multicolored loam in the lower part. The underlying material, to a depth of about 60 inches, is multicolored loamy sand and gravelly loamy sand. In a few areas the depth to sandy or gravelly underlying material is 24 to 32 inches, and in a few small areas it is more than 40 inches.

Included in mapping are soils that are calcareous in the surface layer. These soils make up about 25 percent of the map unit. They are mainly near the Ocheyedan River. Some areas are on slight rises, but many do not occur in a definite pattern. Crop varieties that tolerate excess lime are more productive in these areas.

Permeability is moderate in the upper part and rapid in the lower part. Surface runoff is slow. The available water capacity is moderate. The surface layer is about 5 to 7 percent organic matter. The surface layer generally is mildly alkaline to slightly acid. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 1 to 3 feet.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grains, and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage by wetness. Tiling improves drainage, but tile installation is difficult in places because of caving of sand and gravel. Terraces or a diversion on the slopes above this soil are effective in controlling runoff. Timely field operations are important in maintaining good tilth. Root growth is restricted by the underlying sand or gravel.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIw.

282—Ransom silty clay loam, 1 to 3 percent slopes. This is a very gently sloping, somewhat poorly drained soil in broad, plane upland areas and on the lower part of side slopes. Most areas are irregular in shape and range from about 2 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is about 8 inches thick and is black silty clay loam in the upper part and very dark grayish brown silty clay loam in the lower part. The subsoil is friable and is about 14 inches thick. It is very dark grayish brown and dark grayish brown silty clay loam in the upper part, dark grayish brown and brown silty clay loam in the middle part, and light brownish gray and light yellowish brown silt loam with brownish yellow mottles in the lower part. The underlying material is mainly brownish yellow and yellowish brown loam. In some small areas, sandy or gravelly layers are at a depth of about 3 feet.

Included in mapping are small areas of soils that are calcareous in the surface layer. These soils are mainly on low convex ridges and make up about 4 percent of the map unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 5 or 6 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and

legumes for hay and pasture. Good tilth is easily maintained.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability class is I.

310—Galva silty clay loam, 0 to 2 percent slopes. This is a level, well drained soil on broad ridgetops and in plane to slightly convex areas on drainage divides. Most areas are irregular in shape and range from about 5 to 150 acres in size.

Typically, the surface layer is dark gray silty clay loam about 7 inches thick. The subsurface layer is very dark grayish brown silty clay loam about 6 inches thick. The subsoil is friable and is about 43 inches thick. It is brown and yellowish brown silty clay loam in the upper part and yellowish brown silt loam with light brownish gray mottles in the lower part. The underlying material is mainly yellowish brown loam.

Included in mapping are small areas of soils that generally are droughty because they are underlain by sandy or gravelly material at a depth of about 3 feet.

Permeability is moderate. Surface runoff is slow. The available water capacity is very high. The surface layer is about 3 or 4 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Good tilth is easily maintained.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability class is I.

310B—Galva silty clay loam, 2 to 5 percent slopes. This is a gently sloping, well drained soil on convex upland ridgetops and long side slopes. Most areas are irregular in shape and range from about 10 to 400 acres in size.

Typically, the surface layer is mainly very dark brown silty clay loam about 6 inches thick. The subsurface layer is very dark brown silty clay loam about 5 inches thick. The subsoil is friable and is about 34 inches thick. It is dark brown and brown silty clay loam in the upper part and brown silt loam with a few gray mottles in the lower part. The underlying material is mainly yellowish brown silt loam. In places this soil has a surface layer that is thinner and lighter colored than is typical for this soil.

Included in mapping are small areas of soils that have glacial till or gravelly material in the surface layer. They commonly are more convex than this Galva soil. Also included are small areas of soils that generally are droughty because they are underlain by sandy or gravelly material at a depth of about 3 feet. They do not occur in a definite pattern but generally are more convex than the adjacent Galva soils.

Permeability is moderate. Surface runoff is medium. The available water capacity is very high. The surface layer is about 3 or 4 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion, especially those on longer slopes. Conservation tillage, contouring, and terracing reduce erosion and control runoff (fig. 9). Good tilth is easily maintained.

A few areas are used for hay and pasture. Grasses and legumes for hay and pasture reduce erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIe.

310C2—Galva silty clay loam, 5 to 9 percent slopes, moderately eroded. This is a moderately sloping, well drained soil on lower side slopes and on side slopes above soils that are more sloping. Most areas are irregular in shape and range from about 2 to 15 acres in size.

Typically, the surface layer is very dark brown and dark brown silty clay loam about 7 inches thick. The subsoil is friable and is about 29 inches thick. It is brown silty clay loam in the upper part and brown silt loam in the lower part. The underlying material is light olive brown silt loam to a depth of 49 inches and yellowish brown clay loam with strong brown and reddish yellow mottles to a depth of 60 inches. In places the surface layer is thicker than 10 inches and is darker colored than is typical for this soil.

Included in mapping are small areas of soils that have glacial till in the surface layer. These soils commonly are more convex than the adjacent Galva soils and make up about 5 percent of the map unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is very high. The surface layer is about 2 or 3 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion. Conservation tillage reduces erosion. Contouring and terracing are also effective in reducing erosion but cannot be used where slopes are short. Good tilth is easily maintained.

Figure 9.—Level terraces control erosion and control runoff on Galva silty clay loam, 2 to 5 percent slopes. The crop is corn.

A few areas are used for hay and pasture. Grasses and legumes for hay and pasture reduce erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

311—Galva silty clay loam, stratified substratum, 0 to 2 percent slopes. This is a level, well drained soil. About 60 percent of the areas are on plane uplands, and 40 percent are on stream benches. A few areas are in concave drainageways on uplands. Most areas are irregular in shape; those in drainageways are long and narrow. Most areas range from about 5 to 50 acres, but several are 100 to 200 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is very dark grayish brown silty clay loam about 6 inches thick. The subsoil is friable and is about 41 inches thick. It is brown silty clay loam in the upper part and yellowish brown to light olive brown silt loam in the lower part. The underlying material to a depth of 55 inches is light olive brown silt loam and sand lenses; to a depth of 60 inches it is stratified sand. In some areas the underlying material is silt loam to a depth of more than 60 inches. This soil has a thicker subsoil and has more available phosphorus in the subsoil than other Galva soils.

Included in mapping are soils in small depressions where water ponds. These areas make up about 1 percent of the map unit. Also included are small areas of soils that generally are droughty because they are underlain by sand or gravelly material at a depth of about 3 feet. These areas make up about 1 percent of the unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter and generally is neutral to medium acid. The available phosphorus and available potassium in the subsoil are low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. Good tilth is easily maintained. Root development of most deep-rooted plants is restricted by the sand or gravel at a depth of 40 to 72 inches.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability class I.

311B—Galva silty clay loam, stratified substratum, 2 to 5 percent slopes. This is a gently sloping, well drained soil on stream benches along the larger streams, mostly about 5 to 15 feet above the adjacent bottom lands. Most areas are irregular in shape and range from about 2 to 20 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is very dark

grayish brown silty clay loam about 4 inches thick. The subsoil is friable and is about 40 inches thick. It is very dark grayish brown and brown silty clay loam in the upper part and yellowish brown silty clay loam and silt loam in the lower part. The underlying material is yellowish brown silt loam to a depth of 55 inches and stratified sand and gravel to a depth of 60 inches. On some of the more convex slopes, the surface layer is thinner and lighter colored than is typical.

Included in mapping are small areas of soils that are gravelly in the surface layer. These soils make up about 3 percent of the map unit. Also included are small areas of soils that generally are droughty because they are underlain by sandy or gravelly material at a depth of about 3 feet. These soils commonly are more convex than the adjacent Galva soils. They make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter and generally is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion, especially on longer slopes. Conservation tillage, contouring, and terracing reduce erosion. Good tilth is easily maintained. Root development of most deep-rooted plants is restricted by the sand or gravel at a depth of 40 to 72 inches.

A few areas are used for hay and pasture. Grasses and legumes reduce erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIe.

433D—Storden loam, 9 to 14 percent slopes. This is a strongly sloping, well drained, calcareous soil on short convex side slopes along streams and in large drainageways on uplands. Most areas are much longer than they are wide and range from 2 to 15 acres in size.

Typically, the surface layer is very dark grayish brown loam about 5 inches thick. The layer below that is yellowish brown loam about 4 inches thick. The underlying material is yellowish brown clay loam. In places where this soil is not cultivated it has a thicker and darker surface layer than is typical. In other places the soil is moderately sloping.

Included in mapping are soils that have a surface layer of silt loam that is as much as 12 inches thick. These soils make up about 10 percent of the map unit and are commonly adjacent to soils that formed in loess. Also included are small areas of soils that are sandy loam or loamy sand to a depth of 1 to 2 feet. These soils do not occur in a definite pattern and make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is rapid. The available water capacity is high. The surface layer is about 1 or 2 percent organic matter. The surface layer is moderately or mildly alkaline. In the underlying material the available phosphorus is very low and the available potassium is low. There is excess lime throughout this soil.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture (fig. 10). Erosion is a hazard in cultivated areas. Conservation

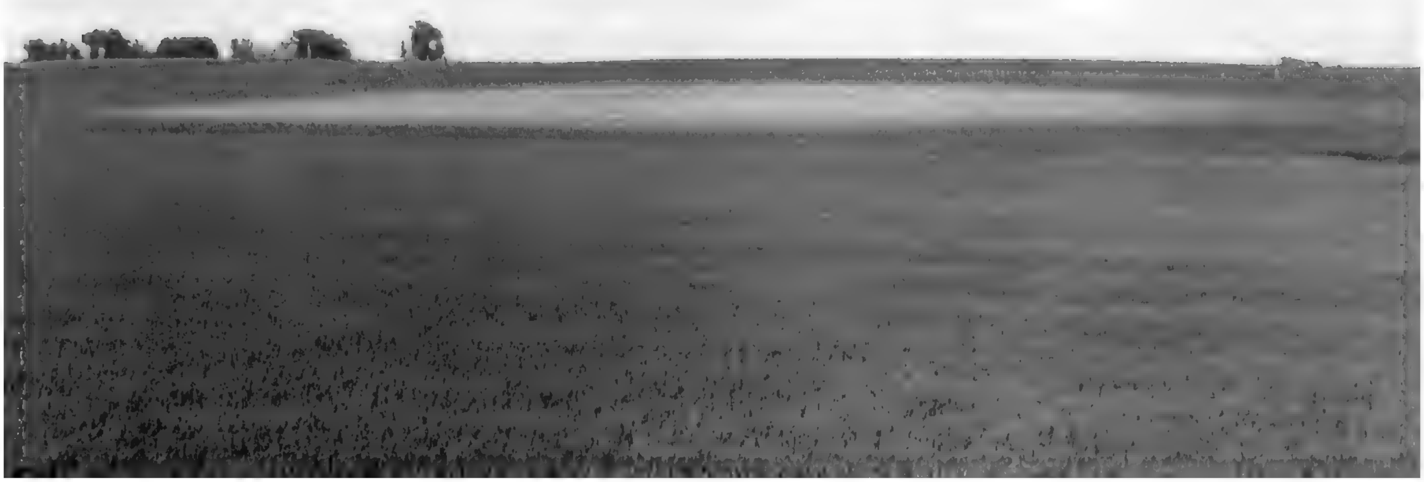

Figure 10.—An area of Storden and Galva soils. The light-colored area in the background is Storden loam, 9 to 14 percent slopes. The crop is oats.

tillage and contouring reduce erosion. Terraces can also be used where the slopes are not too steep or too variable. Good tilth is easily maintained.

Some areas are used for pasture and hay. Grasses and legumes protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

A few areas remain in native hardwoods. Grazing should be controlled in these areas.

The capability subclass is IIIe.

433E—Storden loam, 14 to 18 percent slopes. This is a moderately steep, well drained, calcareous soil on short convex side slopes along streams. Most areas are much longer than they are wide and range from about 2 to 20 acres in size.

Typically, the surface layer is very dark gray loam about 6 inches thick. The next layer is dark grayish brown loam about 4 inches thick. The underlying material is light olive brown clay loam to a depth of 60 inches. In places where this soil is cultivated, the plow layer is dark grayish brown and is about 7 inches thick.

Included in mapping are Everly soils, which have a thicker, darker colored surface layer than this Storden soil. These soils do not have rocks in the surface layer. They make up about 15 percent of the map unit.

Permeability is moderate. Surface runoff is rapid. The available water capacity is high. The surface layer is about 1 or 2 percent organic matter and is moderately alkaline or mildly alkaline. In the underlying material the available phosphorus is very low and the available potassium is low. There is excess lime in the surface layer and below the surface layer.

About 30 percent of this soil is cultivated. This soil is poorly suited to corn, soybeans, and small grains. It is suited to grasses and legumes for hay and pasture. Erosion is a hazard in cultivated areas. Conservation tillage and contouring reduce erosion. Good tilth is easy to maintain.

Most areas are used for pasture and hayland. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

A few areas remain in native hardwoods. Grazing should be controlled in those areas.

This soil is in capability subclass IVe.

433F—Storden loam, 18 to 25 percent slopes. This is a steep, well drained, calcareous soil on side slopes along streams. Most areas on the longer side slopes are irregular in shape; and those on short convex slopes are much longer than they are wide. Most areas range from 3 to 30 acres in size.

Typically, the surface layer is very dark gray loam about 5 inches thick. The next layer is very dark grayish brown clay loam about 4 inches thick. The underlying material is light olive brown clay loam. In places, mainly south-facing slopes, the surface layer is dark grayish brown and is only 3 or 4 inches thick.

Included in mapping are very steep soils that are adjacent to bottom lands. They make up less than 5 percent of the map unit.

Permeability is moderate. Surface runoff is rapid. The available water capacity is high. The surface layer is 1 or 2 percent organic matter and is moderately alkaline or mildly alkaline. In the underlying material the available phosphorus is very low and the available potassium is low. There is excess lime throughout the soil.

This soil is seldom used for cultivated crops. It is poorly suited to corn, soybeans, and small grains and to grasses and legumes for pasture.

Most areas are used for pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

Some areas on north- and east-facing slopes remain in native hardwoods. Grazing should be controlled in those areas.

The capability subclass is VIe.

433G—Storden loam, 25 to 40 percent slopes. This is a very steep, well drained, calcareous soil on side slopes along major streams (fig. 11). Most areas are irregular in shape and range from about 5 to 75 acres in size.

Typically, the surface layer is very dark grayish brown loam about 4 inches thick. The layer below that is about 8 inches thick. It is very dark grayish brown and dark brown loam in the upper part and mainly brown and yellowish brown clay loam in the lower part. The underlying material is mainly yellowish brown, light yellowish brown, and light olive brown clay loam. In places the surface layer is dark grayish brown and is less than 4 inches thick. In some areas this soil is leached of lime to a depth of about 2 feet. These areas are in Waterman Township on wooded or previously wooded slopes that face north or east.

Included in mapping are soils that have slopes of more than 60 percent. They are adjacent to bottom lands and make up less than 5 percent of this map unit.

Permeability is moderate. Surface runoff is rapid. The available water capacity is high. The surface layer is 1 or 2 percent organic matter and is moderately alkaline or mildly alkaline. In the underlying material the available phosphorus is very low and the available potassium is low. There is excess lime throughout this soil.

This soil is seldom used for cultivated crops. It is very poorly suited to corn, soybeans, and small grains. It is poorly suited to grasses and legumes for pasture.

Most areas are used for pasture. Grasses and legumes help protect this soil from erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

Figure 11.—An area of steep and very steep Storden soils along Jordan Creek. The soil on the bottom land is Spillco loam.

Many areas on north- and east-facing slopes remain in native hardwoods. Grazing should be controlled in those areas.

This soil is in capability subclass VIIe.

474B—Bolan loam, 2 to 5 percent slopes. This is a gently sloping, well drained soil on convex upland side slopes and stream benches. Most areas are irregular in shape and range from about 5 to 25 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is about 9 inches thick. It is black and very dark brown loam in the upper part and very dark grayish brown and brown loam in the lower part. The subsoil is friable and very friable and is about 32 inches thick. It is yellowish brown loam in the upper part, yellowish brown sandy loam in the middle part, and yellowish brown loamy sand in the lower part. The underlying material is yellowish brown fine sand. In some small areas this soil has sandy loam or coarser material directly below the surface layer.

Included in mapping are small areas of soils that are sandy or gravelly in the surface layer. These soils make up about 15 percent of the map unit. Also included are small areas of soils that are similar to this Bolan soil except that they tend to be more droughty because they are underlain by sand or gravel at a depth of about 3 feet. These soils make up about 5 percent of the unit. The included soils do not occur in a definite pattern.

Permeability is moderate. Surface runoff is medium. The available water capacity is moderate. The surface layer is about 2 or 3 percent organic matter. It is neutral to medium acid. In the subsoil the available phosphorus and available potassium are very low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops commonly are damaged by drought unless summer rainfall is above average. Erosion is a hazard, especially on the longer slopes. Conservation tillage and contouring reduce erosion. Good tilth is easily maintained. Cuts made to construct terraces expose the sandy loam or loamy sand in places.

A few areas are used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during dry periods help to keep the soil and pasture in good condition.

The capability subclass is IIe.

474C—Bolan loam, 5 to 14 percent slopes. This is a moderately sloping and strongly sloping, well drained soil on convex upland side slopes and stream benches. Most areas are irregular in shape and range from about 2 to 10 acres in size.

Typically, the surface layer is black loam about 5 inches thick. The subsurface layer is very dark grayish brown loam about 4 inches thick. The subsoil is about 39 inches thick. It is brown and yellowish brown, friable loam and sandy loam in the upper part; yellowish brown and brownish yellow, very friable loamy sand in the middle part; and yellowish brown, loose sandy loam in the lower part. The underlying material is light yellowish brown loamy sand and sandy loam. In the areas where this soil has not been cultivated the surface layer is dark colored and thicker than that in cultivated areas. In some areas the surface layer is very dark grayish brown and brown and is not thicker than the plow layer. In places the underlying material is silty.

Included in mapping are small areas of soils that have a sandy or gravelly surface layer. These soils make up about 15 percent of the map unit. Also included are small areas of soils that are generally more droughty than the Bolan soil because they are underlain by sand or gravel at a depth of about 40 inches. These soils do not occur in a definite pattern and make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is moderate. The surface layer is about 2 or 3 percent organic matter. Generally it is neutral to medium acid. The available phosphorus and available potassium in the subsoil are very low.

About 65 percent of this soil is cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. Erosion is a hazard. Cultivated crops are damaged by drought unless summer rainfall is above average. Conservation tillage and contouring reduce erosion. Good tilth is easily maintained. Cuts made to construct terraces expose the sandy loam or loamy sand in places.

About 35 percent of this soil is used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during dry periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

485—Spillville loam, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil on stream bottom lands. It is also along the lower part of some large upland drainageways. Most areas are longer than they are wide and range from about 5 to 50 acres in size. This soil is subject to flooding.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is about 28 inches thick. It is black loam in the upper part and very dark grayish brown light sandy clay loam in the lower part. The next layer is about 12 inches thick. It is mainly very dark grayish brown and dark grayish brown sandy loam. The underlying material is dark grayish brown sandy loam. In a few areas the soil is stratified, and sandy or gravelly material is within a depth of 40 inches. In some small areas, silty deposits are on the surface.

Included in mapping are small areas of Colo and Spillco soils. These soils make up about 15 percent of the map unit. The Colo soils are in old stream channels and other low areas that remain wet and delay tillage. The Spillco soils are near stream channels and are more subject to flooding than the Spillville soils. Also included are small areas of a soil that has a gravelly surface layer. This soil makes up about 2 percent of the unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 5 or 6 percent organic matter. It is neutral or slightly acid. In the lower part of the subsurface layer, the available phosphorus is low and the available potassium is very low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are subject to damage unless the soil is protected from flooding by levees or other flood control measures. Good tilth is easily maintained.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIw.

505—Sperry silty clay loam, 0 to 1 percent slopes. This is a level, very poorly drained soil in concave depressions on uplands. It is subject to ponding (fig. 12). Most areas are circular and range from 1 to 5 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is about 8 inches thick. It is mainly very dark gray silt loam in the upper part and very dark gray silty clay loam in the lower part. The subsoil is about 45 inches thick. In the upper part it is dark grayish brown and olive gray, firm silty clay and has light yellowish brown and brownish yellow mottles; in the middle part it is mottled olive, gray, and brownish yellow, friable silty clay loam; and in the lower part it is mainly gray and olive gray, friable silty clay loam. In a few areas, a loamy or sandy layer is part of the underlying material.

Permeability is slow. Surface water is ponded. The available water capacity is high. The surface layer is about 4 or 5 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphrus is very low and the available potassium is low. A seasonal high water table is at the surface or within 1 foot of the surface.

Most areas of this soil are cultivated. This soil is suited

Figure 12.—Runoff ponded on Sperry silty clay loam, 0 to 1 percent slopes. Primghar and Marcus soils surround the depression. The crop is corn.

to corn, soybeans, and small grains. It is well suited to water-tolerant grasses and legumes for hay and pasture. Crops are subject to damage by ponded water and also by wetness where tile drainage is not adequate. Drainage ditches, surface intakes, and tile are used to remove excess water. Timely field operations are important in maintaining good tilth.

A few areas are used for hay and pasture. Grasses and legumes should be able to withstand wetness. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIw.

577C2—Everly clay loam, 5 to 9 percent slopes, moderately eroded. This is a moderately sloping, well drained soil on side slopes. Most areas are irregular in shape and range from about 2 to 10 acres in size.

Typically, the surface layer is about 7 inches thick. It is very dark brown and dark brown clay loam. The subsoil is friable clay loam and is about 19 inches thick. It is brown in the upper part and yellowish brown in the middle and lower parts. The underlying material is light olive brown and light yellowish brown clay loam. In places where this soil has not been cultivated, the surface layer is thicker and darker than that in cultivated areas, and the upper part of the subsoil is darker. In some areas the surface layer is lighter colored than is typical.

Included in mapping are small areas of soils that have gravel in the surface layer. These soils make up about 10 percent of the map unit. Also included are small areas of soils that are generally droughty because they are underlain by sandy or gravelly material within a depth of 40 inches. These soils make up about 5 percent of the unit and do not occur in a definite pattern.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 2 or 3 percent organic matter and generally is neutral to medium acid. The available phosphorus and available potassium in the subsoil are very low.

Most areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. This soil is subject to damage by erosion, especially on the longer slopes. Good tilth is easily maintained. Contouring and terracing are effective in reducing erosion but cannot be used where slopes are short.

A few areas are used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

577D—Everly clay loam, 9 to 14 percent slopes. This is a strongly sloping, well drained soil on side slopes. Most areas are irregular in shape and range from about 2 to 10 acres in size.

Typically, the surface layer is black clay loam about 5 inches thick. The subsurface layer is black clay loam about 7 inches thick. The subsoil is friable clay loam and is about 16 inches thick. It is very dark gray in the upper part, brown in the middle part, and brown and light olive brown in the lower part. The underlying material to a depth of 48 inches is light olive brown and light yellowish brown clay loam that has gray and brownish yellow mottles. Below that, it is mottled gray, brownish yellow,

and light yellowish brown clay loam to a depth of 60 inches. In cultivated areas, the surface layer is thinner and lighter colored than that in uncultivated areas, and the upper part of the subsoil is lighter colored. In some areas this soil is loam or silty clay loam.

Included in mapping are small areas of soils that have glacial till in the surface layer. These soils make up about 10 percent of the map unit and commonly are more convex than the adjacent Everly soils. Also included are small areas of soils that generally are droughty because they are underlain by sandy or gravelly material within a depth of 40 inches. These soils do not occur in a definite pattern and make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is rapid. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter. The surface layer generally is neutral to medium acid. The available phosphorus and available potassium in the subsoil are very low.

About 25 percent of this soil is cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. This soil is subject to damage by erosion. Conservation tillage, contouring, and terracing reduce erosion. Good tilth is easily maintained.

About 75 percent of this soil is used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

639G—Storden-Salida complex, 25 to 40 percent slopes. This complex consists of very steep, well drained and excessively drained, calcareous soils on side slopes along streams. The areas range from about 5 to 20 acres in size. Storden soils make up 50 to 70 percent of the complex, and Salida soils make up 30 to 50 percent. The two soils are so intricately mixed that it was not practical to separate them in mapping. Salida soils, however, generally are on the higher side slopes, and Storden soils are on mid and lower side slopes.

Typically, the Storden soil has a surface layer of very dark grayish brown loam about 4 inches thick. The layer below that is dark grayish brown loam about 3 inches thick. The underlying material is brown, yellowish brown, and light yellowish brown clay loam to a depth of 72 inches. In some areas a 6- to 12-inch layer of sand and gravel is at the surface.

Permeability is moderate. Surface runoff is very rapid. The available water capacity is high. The surface layer is about 1 or 2 percent organic matter. It is mildly or moderately alkaline. In the underlying material, the available phosphorus is very low and the available potassium is low.

Typically, the Salida soil has a surface layer of black and very dark gray sandy loam about 9 inches thick. It is about 15 percent gravel. The subsoil is about 15 inches thick. It is very dark grayish brown gravelly coarse sandy loam in the upper part and brown sand and gravel in the lower part. The underlying material is yellowish brown and light yellowish brown sand and gravel.

Permeability is very rapid. Surface runoff is rapid. The available water capacity is very low. The surface layer is 0.5 to 1 percent organic matter. It is neutral to moderately alkaline. In the subsoil, the available phosphorus and available potassium are very low.

Included in mapping are areas of soils that have been borrowed, and the gravelly underlying material is exposed. The areas are in an irregular pattern and are less than 2 acres in size. They make up about 5 percent of the complex.

The soils making up this complex are used mainly for pasture or as woodland. These soils are not suited to cultivated crops. Storden soils are too steep and erosive for cultivated crops, and Salida soils are too steep, erosive, and droughty.

The soils are poorly suited to grasses and legumes for pasture, although grasses and legumes reduce erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

Storden soils on many north- and east-facing slopes remain in native hardwoods. Grazing those areas should be controlled.

The capability subclass is VIIe.

708B—Fairhaven silt loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This is a gently sloping, well drained soil on stream benches about 4 to 12 feet above the adjacent bottom lands. Most areas are irregular in shape and range from 2 to 10 acres in size.

Typically, the surface layer is black silt loam about 6 inches thick. The subsurface layer is very dark grayish brown and dark brown silty clay loam about 7 inches thick. The subsoil is friable and is about 16 inches thick. It is brown and yellowish brown silty clay loam in the upper part and yellowish brown loam in the lower part. The underlying material is yellowish brown gravelly sandy loam and pale brown gravelly sand. On some of the more convex slopes, the surface layer is thinner and lighter colored than is typical. In places the surface layer is silty clay loam that is 30 to 34 percent clay.

Included in mapping are small areas of soils that are loamy in the upper part. These soils do not occur in a definite pattern and make up about 10 percent of the map unit. Also included are small areas of soils that have a sandy or gravelly surface layer. These soils make up about 5 percent of the unit. They commonly are in plane or concave areas near the lower edge of the Fairhaven soil, which is adjacent to bottom lands. Some, however, are more convex than the Fairhaven soil.

Permeability is moderate. Surface runoff is medium. The available water capacity is moderate. The surface layer is about 3 or 4 percent organic matter. Generally it

is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are damaged by drought in some years. This soil is subject to damage by erosion, especially on the longer slopes. Conservation tillage and contouring are effective in reducing erosion. Good tilth is easily maintained. Terraces generally are not constructed if erosion can be controlled by other means. Terrace channel cuts expose the coarse textured, unproductive material in places. Root growth is restricted by the underlying sand or gravel.

A few areas are used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates, rotation grazing, and restricted grazing during dry periods help to keep the soil and pasture in good condition.

The capability subclass is IIe.

708C2—Fairhaven silt loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded. This is a moderately sloping, well drained soil on stream benches about 4 to 12 feet above the adjacent bottom lands. The areas are irregular in shape and range from about 2 to 12 acres in size.

Typically, the surface layer is silt loam and silty clay loam about 9 inches thick. It is very dark grayish brown. The subsoil is friable silty clay loam about 18 inches thick. It is brown in the upper part, dark yellowish brown in the middle part, and yellowish brown in the lower part. The underlying material is gravelly sand and gravelly sandy loam. It is yellowish brown in the upper part and brown in the lower part. In some areas on the lower part of the slope the surface layer is more than 9 inches thick. In places the surface layer is silty clay loam that is 30 to 34 percent clay.

Included in mapping are Fairhaven soils that are more than 32 inches deep to sand and gravel. These soils make up about 15 percent of the map unit and do not occur in a definite pattern. Also included are small areas of soils that have a sandy or gravelly surface layer. These soils commonly are in plane and concave areas near the lower boundary of this Fairhaven soil, which adjoins the bottom lands. In some places these soils are more convex than the Fairhaven soil.

Permeability is moderate. Surface runoff is medium. The available water capacity is moderate. The surface layer is 2 or 3 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Some areas of this soil are cultivated. This soil is suited to corn, soybeans, and small grains. It is well suited to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion. Conservation tillage and contouring reduce erosion. In some places, contouring is difficult because of short uneven slopes. Terraces generally are not constructed on this soil if erosion can be controlled by other means. Terrace channel cuts expose coarse textured, unproductive material in places. Crops are damaged by drought unless summer rainfall is above average. Root growth is restricted by the underlying sand or gravel.

Some areas are used for hay and pasture. Grasses and legumes for hay and pasture help protect this soil from erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

The capability subclass is IIIe.

709—Fairhaven silt loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This is a nearly level, well drained soil on stream benches about 4 to 12 feet above the adjacent bottom lands. Most areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is black silt loam about 6 inches thick. The subsurface layer is very dark brown and very dark grayish brown silty clay loam about 10 inches thick. The subsoil is friable and about 21 inches thick. It is very dark grayish brown and brown silty clay loam in the upper part and yellowish brown clay loam in the lower part. The underlying material is light yellowish brown sand. In places the surface layer is silty clay loam that is 30 to 34 percent clay.

Included in mapping are small areas of soils that have coarse textured underlying material at depths of less than 32 inches or more than 40 inches. The depth to coarse textured material tends to be less in convex areas and more in concave areas. These soils make up about 10 percent of the map unit. Also included are soils that are more sandy and have a slightly lower available water capacity. These soils make up less than 5 percent of the unit. Their pattern is irregular.

Permeability is moderate. Surface runoff is slow. The available water capacity is moderate. The surface layer is about 3 or 4 percent organic matter. Generally it is neutral to medium acid. The available phosphorus and available potassium in the subsoil are low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture. A few cultivated areas are subject to damage by runoff from adjacent soils. Good tilth is easily maintained. Root growth is restricted by the underlying sand or gravel.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability class is I.

709B—Fairhaven silt loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes. This is a gently sloping, well drained soil on stream benches about 4 to 12 feet above the adjacent bottom lands. Most areas are

irregular in shape and range from about 2 to 15 acres in size.

Typically, the surface layer is black silt loam about 8 inches thick. The subsurface layer is dark brown silty clay loam about 3 inches thick. The subsoil is friable and is about 25 inches thick. It is mainly yellowish brown silty clay loam in the upper part, yellowish brown and light olive brown silt loam in the middle part, and light olive brown loam in the lower part. The underlying material is light olive brown and light yellowish brown gravelly loamy sand and gravelly sand that is about 20 to 45 percent gravel. On some of the more convex slopes the surface layer is thinner and lighter colored than is typical. In places the surface layer is silty clay loam that is 30 to 34 percent clay.

Included in mapping are soils that are more sandy and have a slightly lower available water capacity. These soils do not occur in a definite pattern. They make up about 15 percent of the map unit. Also included are small areas of soils that have a sandy or gravelly surface layer. Those soils commonly are near the lower boundary of this Fairhaven soil next to the stream bottom lands. They make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is moderate. The surface layer is about 3 or 4 percent organic matter. Generally it is neutral to medium acid. In the subsoil the available phosphorus is very low and the available potassium is low.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas on the longer slopes are subject to damage by erosion, especially if the areas receive runoff from soils on adjacent hillsides. Conservation tillage, contouring, and terracing reduce erosion. Good tilth is easily maintained. Terraces generally are not constructed on this soil if erosion can be controlled by other means mainly because the coarse textured material is exposed in the terrace channel cuts. Root growth is restricted by the underlying sand or gravel.

A few areas are used for hay and pasture. Grasses and legumes protect the soil from erosion and retard runoff. Proper stocking rates and rotation grazing help keep the soil and pasture in good condition.

The capability subclass is IIe.

733—Calco silty clay loam, 0 to 2 percent slopes. This is a level, poorly drained calcareous soil on bottom lands and in the lower part of upland drainageways. It is subject to flooding. The areas in the upland drainageways are relatively long and narrow, and those on bottom lands are irregular in shape. Most areas range from about 10 to 100 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is black silty clay loam about 42 inches thick. The underlying material is black and very dark gray silty clay loam. In a few areas the lower part of the surface layer and the underlying material are dark gray and dark grayish brown. In many areas, this soil is calcareous only in the upper 10 to 20 inches.

Included in mapping are areas where recent, neutral or mildly alkaline sediment 8 to 15 inches thick overlies buried Calco soils. These areas do not occur in a definite pattern. They make up about 3 percent of the map unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 5 to 7 percent organic matter. Generally it is moderately alkaline or mildly alkaline. In the subsurface layer the available phosphorus is very low and the available potassium is low. This soil is calcareous throughout. A seasonal high water table is at a depth of 1 to 3 feet.

This soil is used mainly for cultivated crops. In the narrow bottom lands it is mainly in pasture. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are subject to damage by wetness, and in some places by flooding and siltation. Tile or drainage ditches are used in places to correct the wetness. Timely field operations are important in maintaining good tilth. Soybean varieties that can tolerate excess lime should be selected for this soil.

In a few areas this soil is used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This soil is in capability subclass IIw.

785—Spillco loam, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil on bottom lands. It is also along the lower part of some large drainageways on the uplands. Most areas are longer than they are wide and range from 10 to 75 acres in size. This soil is subject to flooding.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is about 30 inches thick. It is black loam in the upper and middle parts and very dark brown loam in the lower part. The next layer is about 6 inches thick. It is very dark grayish brown loam. The underlying material is dark grayish brown and very dark grayish brown sandy loam.

Included in mapping are soils that are calcareous throughout. These soils commonly are one to several feet lower on bottom lands than the Spillco soil, generally are nearer to the stream channel, and flood more frequently. These soils make up about 15 percent of the map unit. Also included are Colo soils in old stream channels and other low areas. These soils make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 5 or 6 percent organic matter. Generally it is neutral or slightly acid. In the lower part of the subsurface layer, the available phosphorus is low and

the available potassium is very low. A seasonal high water table is at a depth of 3 to 5 feet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Crops are subject to damage by flooding. Good tilth is easily maintained. In areas where this soil is calcareous, soybean varieties should tolerate excess lime, and pesticides applied to the soil should be effective under the excess lime conditions.

Some areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

The capability subclass is IIw.

878B—Ocheyedan loam, 2 to 5 percent slopes. This is a gently sloping, well drained soil on uplands, mainly on side slopes near larger streams. Most areas are irregular in shape and range from about 2 to 20 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is about 9 inches thick. It is very dark brown and very dark gray in the upper part and very dark grayish brown and very dark gray loam in the lower part. The subsoil is friable and is about 44 inches thick. It is brown, very dark grayish brown, and yellowish brown loam in the upper part, yellowish brown sandy clay loam in the middle part, and mainly yellowish brown and light olive brown silt loam in the lower part. In a few areas the soil is nearly level. In other small areas the surface layer is thinner and lighter colored than is typical.

Included in mapping are small areas of soils that have a sandy surface layer. These soils make up about 10 percent of the map unit. Also included are small areas of soils that generally are droughty because they are underlain by sandy or gravelly material at a depth of about 3 feet. These soils do not occur in a definite pattern and make up about 5 percent of the unit.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 3 or 4 percent organic matter. The surface layer is neutral to medium acid. The available phosphorus and potassium in the subsoil are very low.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Cultivated areas are subject to damage by erosion, especially those on longer slopes. Conservation tillage, contouring, and terracing reduce erosion. Good tilth is easily maintained.

A few areas are used for hay and pasture. Grasses and legumes help protect the soil from erosion and retard runoff. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition.

The capability subclass is IIe.

1658C—Terril-Colo complex, channeled, 2 to 10 percent slopes. This complex consists of sloping, poorly drained and moderately well drained soils in narrow valleys. The areas commonly are long and narrow and range from about 5 to 20 acres in size. Terril soils make up about 40 percent of the complex, Colo soils make up 40 percent, and Spillville soils make up 20 percent. Terril soils are on upland drainageways, foot slopes, and alluvial fans. Colo soils are on bottom lands and in lower drainageways. Colo soils are subject to flooding.

Typically, the Terril soil has a surface layer of black loam about 6 inches thick. The subsurface layer is about 32 inches thick. It is black loam in the upper part and black and very dark brown loam in the lower part. The subsoil is friable clay loam more than 22 inches thick. It is very dark brown in the upper part and very dark grayish brown and very dark gray in the lower part. In a few places the surface layer is less than 24 inches thick.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 4 or 5 percent organic matter. Generally it is neutral or slightly acid. In the lower part of the subsurface layer, the available phosphorus is very low and the available potassium is low.

Typically, the Colo soil has a surface layer of black silty clay loam about 5 inches thick. The subsurface layer is about 37 inches thick. It is black silty clay loam in the upper part and very dark gray silty clay loam with a few brown mottles in the lower part. The layer below that is about 16 inches thick. It is very dark gray silty clay loam and has a few brown mottles. The underlying material is gray and light olive gray silty clay loam.

Permeability is moderate. Surface runoff is medium. The available water capacity is high. The surface layer is about 5 to 7 percent organic matter. Generally it is neutral. In the lower part of the subsurface layer, the available phosphorus is low and the available potassium is low. A seasonal high water table is at a depth of 1 to 3 feet.

The soils making up this complex are used mainly for pasture. They are impractical to farm in most places because of stream channels, which dissect the areas. The soils are suited to grasses and legumes for pasture. The grasses and legumes help reduce erosion and retard runoff. Good tilth is easily maintained. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

In a few areas the soils remain in native hardwood trees. Grazing in those areas should be controlled.

The capability subclass is Vw.

1785—Spillco loam, channeled, 0 to 2 percent slopes. This is a level, somewhat poorly drained soil on the bottom lands of larger streams. Most areas are adjacent to the present stream channel about 2 to 8 feet below adjacent soils on bottom lands. The areas are dissected by old channels. Most areas are irregular in shape and range from 5 to 35 acres in size. This soil is subject to flooding.

Typically, the surface layer is black loam about 6

inches thick. The subsurface layer is about 47 inches thick. It is very dark gray loam in the upper part and black loam in the lower part. The next layer is about 9 inches thick. It is friable very dark gray loam. In most areas there is some stratification in the upper part of the profile. In a few areas there are recent sandy deposits on the surface.

Included in mapping are small areas of Spillville soils in higher positions on the bottom lands and small areas of Colo and Calco soils in old stream channels. These soils each make up about 5 percent of the unit. Also included are low areas of recent stratified sandy deposits. These soils make up about 10 percent of the unit.

Permeability is moderate. Surface runoff is slow. The available water capacity is high. The surface layer is about 2 or 3 percent organic matter. It is mildly or moderately alkaline. The available phosphorus and potassium in the lower part of the subsurface layer are very low. A seasonal high water table is at a depth of 1 to 3 feet.

In a few areas this soil is used for cultivated row crops. This soil is impractical to farm unless the old and meandering stream channels on the soil are filled or straightened. This soil is subject to more frequent flooding and deposition than the other soils on bottom lands. Good tilth is easily maintained.

This soil is used mainly for pasture. It is suited to grasses and legumes. Proper stocking rates and rotation grazing help to keep the soil and pasture in good condition. Grasses and legumes planted for pasture should be tolerant of frequent, brief flooding and of siltation.

Some areas of this soil remain in trees. Grazing should be controlled in those areas.

The capability subclass is Vw.

5010—Pits, gravel. This map unit is on bottom lands, stream terraces, and uplands where sand and gravel have been mined. Most areas are approximately square or rectangular and range from 2 to 10 acres in size. A few areas range from 15 to 20 acres in size.

Typically, the material remaining in the mined pits is sand or loamy sand and has a high proportion of gravel. In many areas, cobbles and stones make up small piles or are scattered on the surface. In a few places where most of the sand and gravel has been removed, the remaining material is loam or clay loam.

Included in mapping are small areas where water ponds. These areas make up about 5 percent of the unit. Also included near the boundaries of this unit are many narrow areas that are moderately steep to very steep. These areas make up 2 percent of the unit.

Most areas of this map unit are either wasteland or are being mined for sand and gravel. Areas that were mined a number of years ago generally have a vegetative cover and are suitable for use as habitat for wildlife. This unit is not suited to cultivated crops, hay, or pasture.

This unit is not assigned to a capability subclass.

5040—Orthents, loamy. These are nearly level and gently sloping, well drained soils on uplands and stream benches where part or all of the original soil has been removed. In most areas, some soil material has been replaced. Most areas are approximately square or rectangular and range from 2 to 20 acres in size. A few areas range from 30 to 60 acres in size.

No one profile is typical of this map unit, but in one of the most common profiles the surface layer is silty clay loam about 12 inches thick. It consists mainly of mixed material from the surface layer and subsoil of the soil in the area before material was removed. The underlying material varies greatly from place to place. On uplands it is commonly firm clay loam glacial till, but in places there is as much as 1 1/2 feet of friable silt loam and silty clay loam between the surface layer and the glacial till. On stream terraces the underlying material is commonly friable silty or loamy mixed material 1/2 to 2 feet thick over sandy or gravelly material.

Included in mapping are areas where firm clay loam or loam glacial till is within 6 inches of the surface. These areas make up about 10 percent of the unit. Also included are areas that were formerly used for solid waste disposal. These areas make up about 10 percent of the unit. The surface layer in these areas is highly variable, depending on the kind and amount of fill used to cover the solid waste. The included areas do not occur in a consistent pattern.

Permeability generally ranges from moderately rapid to moderately slow. Surface runoff is medium. The available water capacity is low to moderate. The surface layer is about 1 to 2 percent organic matter. It is neutral or slightly acid. The available phosphorus and potassium in the underlying material are very low.

In some areas, these soils are cultivated. They are well suited to poorly suited to corn, soybeans, and small grains. They are also well suited to poorly suited to grasses and legumes for hay and pasture. The yields of cultivated crops generally are higher in areas where grasses and legumes have been grown for several years after borrow areas have been reclaimed. Grasses and legumes are especially helpful in improving the soil where the new surface layer is low in content of organic matter or where firm glacial till is at a depth of less than 2 feet. In areas where there is less than 2 feet of backfilled soil material over exposed glacial till, cobbles and stones move up into the surface layer and are a common hazard to tillage. In areas where there is less than 3 feet of backfilled soil material over coarse textured layers, drought is a hazard.

In a few areas, the soils are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted grazing during wet periods help to keep the soil and pasture in good condition.

This unit is not assigned to a capability subclass.

use and management of the soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

crops and pasture

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed soil map units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

In 1974 in O'Brien County, approximately 356,000 acres was used for crops and pasture, according to the 1974 Census of Agriculture. About 147,000 acres was used for corn, 108,000 acres for soybeans, 9,900 acres for oats, and 9,200 acres for alfalfa. The acreage of corn and soybeans has increased in the past 10 years, and the acreage of oats, alfalfa, and pasture has decreased.

The potential of the soils for increased efficiency in crop production is good, through both new crop production technology and better use of present crop production technology.

New crop production technology includes irrigation, which is most beneficial on terrace soils, such as Estherville and Fairhaven soils. These soils have a lower available water capacity than most upland soils in the county. The amount of water needed for irrigation is more likely to be found in terrace and bottom land areas than on uplands.

Present crop production technology can be more effective on many farms if cropland is managed according to the major soil or group of soils in each field. If individual soil areas are too small to be managed separately, areas of different soils can be grouped and management based on the properties of the most extensive soils and their effect on the intended use. The soils should be grouped according to slope, drainage, and the content of organic matter. In a few places the soils should be grouped on the basis of similar pH values, texture, and available water capacity.

Slope is related to differences in other soil properties and to differences in management needed for crop production. Because of slope, erosion is a major problem on about 40 percent of the cropland in the county. Cultivated soils are subject to erosion if the slope is more than 2 percent. Galva and Sac soils are the most extensive soils in the county that are used for cultivated crops and that are subject to erosion.

Erosion removes part of the topsoil and the fertilizers and pesticides that have been applied. The sediment that results from erosion fills swales and low areas in the field, and some is carried into streams.

Erosion is controlled by practices that increase the surface cover, reduce runoff, and increase infiltration. On fields of row crops, tillage that leaves crop residue on

the surface reduces erosion. On livestock farms, erosion is reduced by grass and legume forage crops. Although there has been a decrease in the acreage of grass and legume forage crops, there has been an increase in cropland that is cultivated with chisel plows and other implements that leave crop residue on the surface.

In many areas of Galva and Sac soils and in some areas of other well drained soils in the county, slopes are long and uniform enough that terraces and contour tillage are practical. Many of the more recently installed terraces are parallel and have tile outlets. Although crop rows do not exactly follow the contour, slopes between each terrace are short, and thus erosion is controlled. Terraces are not practical on Estherville soils or, in most places, on Bolan and Fairhaven soils because terrace cuts expose the coarse textured, unproductive material.

Contour tillage is most effective in combination with terraces. Where slopes are uniform enough to make it practical, contour tillage by itself can reduce erosion. Information and help in designing erosion control practices are available at the local office of the Soil Conservation Service.

Artificial tile drainage is needed for cultivated crops on the poorly drained soils, for example, Afton and Marcus soils. Poorly drained soils make up about 21 percent of O'Brien County. Tile drainage on somewhat poorly drained soils, for example, Primghar and Ranson soils, is beneficial in some years, mainly because it allows more timely tillage. On these soils, however, in some years the tile removes water that would benefit the crop later in the growing season. Some areas of poorly drained and somewhat poorly drained soils that are near farmsteads are used for pasture and need little or no artificial drainage. Information and help in designing artificial drainage systems are available at the local office of the Soil Conservation Service.

Sampling soil for fertility testing is an important part of cropland management. Samples from different soils that have similar properties are combined for testing, especially if the soil areas will receive the same management. Samples from soils that have different properties generally should not be combined, even where the same general management is planned. A separate analysis of each soil or group of similar soils generally gives the best estimate of the fertility of a field. Soils of minor extent in a field that have properties different from those of the major soils need not be sampled unless different management is planned for them. More specific information on soil sampling for fertility testing is available at the local office of the Cooperative Extension Service.

yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils.

land capability classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops (*29*). Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for woodland and for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, woodland, wildlife habitat, or recreation.

The acreage of soils in each capability class and subclass is shown in table 6. The capability classification of each map unit is given in the section "Detailed soil map units."

windbreaks and environmental plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, hold snow on the fields, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To insure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 7 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 7 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a nursery.

recreation

O'Brien County has a number of areas of scenic and historical interest. These areas are used for camping, hiking, hunting, fishing, nature study, nonpowered boating, picnicking, sightseeing, and swimming. Public parkland administered by the County Conservation Board includes Bruegman Area, Covey Area, Dog Creek Park, Douma Pit Access, Litka Area, Mill Creek Park, Peterson Area, and Wall Area. Each town in the county maintains a municipal park.

Although the largest streams in the county—the Little Sioux River, Ocheyedan River, and Waterman Creek—are not bordered by public land, they are used for limited boating and fishing. There are a number of watershed impoundments and farm ponds on private land; fishing is by permission of the landowner. There are several 9-hole golf courses in the county.

The potential for development of additional recreation facilities throughout the county is good. The greatest potential for development of most kinds of recreation facilities is in areas of the Storden-Galva-Sac association. The hilly terrain, wooded slopes, and proximity to streams provide a variety of possibilities for recreation. This association is described under "General soil map units."

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 8, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning,

design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

Camp areas require site preparation such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking, horseback riding, and bicycling should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

wildlife habitat

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 9, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, orchardgrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil

properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, apple, hawthorn, dogwood, hickory, blackberry, and elderberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants furnish browse, seeds, and cones. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, cordgrass, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite, Hungarian partridge, pheasant, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, shore birds, muskrat, mink, and beaver.

engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

building site development

Table 10 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and

without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

sanitary facilities

Table 11 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 11 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and that good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to effectively filter the effluent. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid

and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 11 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 11 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

construction materials

In table 12 the soils are rated *good, fair,* or *poor* as a source of roadfill, sand, gravel, and topsoil. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 12, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are a gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering properties.

A soil rated as a good source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an unsuitable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel or stones, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

water management

Table 13 gives information on the soil properties and site features that affect water management. The kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the data apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The data do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders or organic matter. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as high content of calcium carbonate. Availability of drainage outlets is not considered.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a

cemented pan. The performance of a system is affected by the depth of the root zone and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

soil properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics. These results are reported in table 17.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

engineering properties

Table 14 gives estimates of the engineering classification and of the range of properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and their morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains particles coarser than sand, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (*1*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as Pt. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 17.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

physical and chemical properties

Table 15 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops.

They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 15, the estimated content of organic matter of the plow layer is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

soil and water features

Table 16 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt and water in swamps and marshes are not considered flooding.

Table 16 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs on an average of once or less in 2 years; and *frequent* that it occurs on an average of more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a

seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 16 are the depth to the seasonal high water table; the kind of water table—that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 16.

An apparent water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An artesian water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A perched water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

engineering test data

Table 17 shows laboratory test data for several pedons sampled at carefully selected sites in the survey area. The pedons are typical of the series and are described in the section "Soil series and their morphology." The soil samples were tested by the Soil Testing Laboratory, Iowa State Department of Transportation.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM).

The tests and methods are: AASHTO classification—M 145 (AASHTO), D 3282 (ASTM); Mechanical analysis—T 88 (AASHTO), D 2217 (ASTM); Liquid limit—T 89 (AASHTO), D 423 (ASTM); Plasticity index—T 90 (AASHTO), D 424 (ASTM); Moisture density, Method A—T 99 (AASHTO), D 698 (ASTM).

classification of the soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*31*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. In table 18, the soils of the survey area are classified according to the system. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Aquoll (*Aqu*, meaning water, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Haplaquolls (*Hapl*, meaning minimal horizonation, plus *aquoll*, the suborder of the Mollisols that have an aquic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Haplaquolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, mesic Typic Haplaquolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

soil series and their morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (*28*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*31*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed soil map units."

Afton series

The Afton series consists of poorly drained, moderately slowly permeable soils in drainageways on uplands. These soils formed in silty alluvium and loess. Slope ranges from 0 to 2 percent.

Afton soils are similar to Colo and Marcus soils and commonly are adjacent on the landscape to Colo, Galva, and Marcus soils. Colo soils have a mollic epipedon thicker than 40 inches and are on bottom lands and on the larger drainageways below Afton soils. Galva soils are well drained, have a mollic epipedon less than 20 inches thick, and are on hillsides above Afton soils.

Marcus soils have a mollic epipedon less than 24 inches thick and are on drainageways above Afton soils.

Typical pedon of Afton silty clay loam, 0 to 2 percent slopes, in a cultivated field, 2,085 feet west and 325 feet south of the northeast corner of sec. 20, T. 96 N., R. 42 W.

Ap—0 to 7 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; clear smooth boundary.

A12—7 to 17 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to moderate very fine subangular blocky; friable; neutral; gradual smooth boundary.

A3—17 to 26 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak medium subangular blocky structure parting to moderate fine and very fine subangular blocky; friable; mildly alkaline; clear wavy boundary.

B21g—26 to 31 inches; olive gray (5Y 5/2) silty clay loam; faces of peds are dark gray (5Y 4/1) and gray (5Y 5/1); common fine distinct light olive brown (2.5Y 5/6) mottles; weak fine prismatic structure parting to moderate fine subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

B22g—31 to 41 inches; olive gray (5Y 5/2) silty clay loam; common fine prominent yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate fine subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

B3g—41 to 51 inches; olive gray (5Y 5/2) silty clay loam; common fine prominent yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

Cg—51 to 60 inches; olive gray (5Y 5/2) silt loam; few fine prominent yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to massive; friable; few fine black segregations (oxides); slight effervescence; few very fine lime concretions in the lower part; moderately alkaline.

The solum is 40 to 55 inches thick. Free carbonates are at a depth of 36 to 55 inches. The mollic epipedon is 24 to 32 inches thick.

The A horizon has color value of 2 or 3 and chroma of 0 or 1.

The B2g horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 or less. Mottles in this horizon are few to many and have chroma of 1 to 8. Reaction is neutral or mildly alkaline.

The Cg horizon is the same color as the B2g horizon. In places this horizon is loam or clay loam glacial till within a depth of 50 inches. Effervescence is slight or strong.

Biscay series

The Biscay series consists of poorly drained, moderately permeable soils on low stream benches. These soils formed in silty and loamy alluvium that is 32 to 40 inches thick over sandy and gravelly sediment. Slope ranges from 0 to 2 percent.

Biscay soils are similar to Cylinder soils and commonly are adjacent on the landscape to Calco, Colo, and Cylinder soils. Calco and Colo soils have a mollic epipedon thicker than 36 inches and are on bottom lands below Biscay soils. Cylinder soils are somewhat poorly drained and are on stream benches above Biscay soils.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated field 1,310 feet west and 85 feet north of the southeast corner of sec. 4, T. 96 N., R. 41 W.

Ap—0 to 7 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; cloddy parting to weak very fine granular structure; friable; mildly alkaline; clear smooth boundary.

A12—7 to 12 inches; very dark gray (10YR 3/1) and black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry, very dark gray (10YR 3/1) kneaded; few very fine distinct brown (7.5YR 4/4) mottles; weak fine subangular blocky structure parting to weak very fine granular; friable; mildly alkaline; gradual smooth boundary.

A3—12 to 18 inches; very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) silty clay loam, dark gray (10YR 4/1) and grayish brown (2.5Y 5/2) dry; a few faces of peds are black (10YR 2/1); very dark gray (10YR 3/1) kneaded; few very fine distinct dark yellowish brown (10YR 4/4) and dark brown (7.5YR 4/4) mottles; weak fine subangular blocky structure parting to weak fine granular; friable; mildly alkaline; clear wavy boundary.

B21—18 to 23 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) clay loam; faces of peds are very dark grayish brown (2.5Y 3/2); dark grayish brown (2.5Y 4/2) kneaded; few fine faint light brownish gray (2.5Y 6/2) and very fine distinct dark yellowish brown (10YR 4/4) and dark brown (7.5YR 4/4) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky and granular; friable; mildly alkaline; gradual wavy boundary.

B22—23 to 29 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/3) loam, dark grayish brown (2.5Y 4/2) kneaded; common fine distinct light yellowish brown (2.5Y 6/3) and few very fine prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

B3—29 to 37 inches; mottled olive (5Y 5/3) and light brownish gray (2.5Y 6/2) loam; faces of peds are grayish brown (2.5Y 5/2); common fine prominent brownish yellow (10YR 6/6 & 6/8) and few fine distinct gray (2.5Y 6/1) mottles; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; clear wavy boundary.

IIC1—37 to 41 inches; mottled light olive brown (2.5Y 5/3), light brownish gray (2.5Y 6/2), and brownish yellow (10YR 6/6 & 6/8) loamy sand and about 15 percent gravel; single grained; loose, few fine black segregations (oxides); slight effervescence; mildly alkaline; gradual wavy boundary.

IIC2—41 to 48 inches; light yellowish brown (2.5Y 6/3) gravelly loamy sand and about 30 percent gravel; single grained; loose; few gravel sized silt bodies; strong effervescence; moderately alkaline; gradual wavy boundary.

IIC3—48 to 53 inches; grayish brown (2.5Y 5/2) gravelly loamy sand and about 20 percent gravel; few fine prominent brownish yellow (10YR 6/6 & 6/8) mottles; single grained; loose; strong effervescence; moderately alkaline; gradual wavy boundary.

IIC4—53 to 60 inches; light yellowish brown (2.5Y 6/4) gravelly loamy sand; single grained; loose; strong effervescence; moderately alkaline.

The solum is 32 to 40 inches thick. Sand and gravel are at a depth of 32 to 40 inches. Free carbonates commonly are at a depth of 32 to 40 inches, but in some pedons they are also in the A horizon. The mollic epipedon is 16 to 24 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or is N 2/0. It is dominantly silty clay loam, but the range includes clay loam.

The B2 horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 to 3. It is clay loam or loam. Reaction is neutral or mildly alkaline.

The IIC horizon has value of 5 or 6 and chroma of 2 to 4. It commonly is loamy sand or sand and 15 to 50 percent gravel but in some pedons is less than 10 percent gravel.

Bolan series

The Bolan series consists of well drained, moderately permeable soils on uplands. These soils formed in loamy and sandy eolian sediment. Slope ranges from 2 to 14 percent.

Bolan soils are similar to Ocheyedan soils and commonly are adjacent on the landscape to Galva and Ocheyedan soils. Galva soils formed in loess and are above Bolan soils. Ocheyedan soils average more than 18 percent clay between depths of 10 and 40 inches and commonly are above Bolan soils on the landscape.

Typical pedon of Bolan loam, 2 to 5 percent slopes, in a cultivated field 1,430 feet north and 170 feet east of the southwest corner of sec. 26, T. 94 N., R. 29 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

A12—7 to 11 inches; black (10YR 2/1) and very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) and brown (10YR 6/3) dry, very dark brown (10YR 2/2) kneaded; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; slightly acid; gradual smooth boundary.

A3—11 to 16 inches; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) loam, brown (10YR 5/3) and pale brown (10YR 6/3) dry, very dark grayish brown (10YR 3/2) kneaded; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; slightly acid; gradual boundary.

B21—16 to 22 inches; yellowish brown (10YR 5/4) loam; faces of peds are brown (10YR 4/3); weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; slightly acid; gradual wavy boundary.

B22—22 to 28 inches; yellowish brown (10YR 5/4) sandy loam; weak fine prismatic structure parting to weak very fine prismatic and subangular blocky; friable; slightly acid; gradual wavy boundary.

B23—28 to 35 inches; yellowish brown (10YR 5/4) sandy loam; very weak medium prismatic structure parting to weak fine prismatic and subangular blocky; very friable; slightly acid; gradual wavy boundary.

B3—35 to 48 inches; yellowish brown (10YR 5/4) loamy sand; weak and very weak medium prismatic structure parting to single grained; very friable; slightly acid; gradual wavy boundary.

C—48 to 60 inches; yellowish brown (10YR 5/4) fine sand; single grained; loose; slightly acid.

The solum is 36 to 48 inches thick. Free carbonates commonly are at a depth of more than 48 inches. The mollic epipedon is 11 to 17 inches thick. The weighted average clay content between depths of 10 and 40 inches is 14 to 18 percent.

The A horizon has color value of 2 or 3 and chroma of 2. It is loam that consists of 14 to 20 percent clay.

The B2 horizon has value of 4 or 5 and chroma of 4 to 6. It is loam or fine sandy loam that consists of 12 to 16 percent clay. Reaction is neutral or slightly acid.

The C horizon has value of 4 or 5 and chroma of 4 to 6. It is neutral or slightly acid.

Calco series

The Calco series consists of poorly drained, moderately permeable soils on stream bottom lands.

These soils formed in silty calcareous alluvium. Slope ranges from 0 to 2 percent.

Calco soils are similar to Colo soils and commonly are adjacent on the landscape to Colo and Spillco soils. Colo soils are noncalcareous. Spillco soils formed in loamy alluvium and commonly are on higher bottom lands nearer to the stream than Calco soils.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes, 400 feet north and 135 feet east of the southwest corner of sec. 10, T. 97 N., R. 42 W.

A11—0 to 6 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate very fine granular structure; friable; slight effervescence; moderately alkaline; clear smooth boundary.

A12—6 to 16 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

A13—16 to 26 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

A14—26 to 36 inches; black (10YR 2/1) silty clay loam; weak medium subangular blocky structure parting to weak very fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

A15—36 to 48 inches; black (10YR 2/1) silty clay loam; weak medium prismatic structure parting to weak fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

C—48 to 60 inches; black (10YR 2/1) grading with depth to very dark gray (10YR 3/1) silty clay loam; very weak medium prismatic structure; strong effervescence; moderately alkaline.

The thickness of the solum and that of the mollic epipedon range from 40 to 50 inches. Some pedons do not have free carbonates below a depth of 24 inches.

The A horizon has color value of 2 or 3 and chroma of 0 or 1. It is silty clay loam that consists of 30 to 35 percent clay. In the subhorizons in some pedons the clay content is less than 30 percent. In some pedons the A horizon contains snail shells and snail shell fragments.

The color range in the C horizon is the same as in the A horizon. The C horizon has mottles in some pedons.

Colo series

The Colo series consists of poorly drained, moderately permeable soils on bottom lands along streams. These soils formed in silty alluvium. Slope ranges from 0 to 2 percent.

Colo soils are similar to Calco soils and commonly are adjacent on the landscape to Calco, Spillco, and Spillville soils. Calco soils are calcareous throughout the solum. Spillco and Spillville soils formed in loamy alluvium, are somewhat poorly drained, and commonly are above Colo soils on the landscape.

Typical pedon of Colo silty clay loam, 0 to 2 percent slopes, 1,770 feet north and 170 feet east of the southwest corner of sec. 31, T. 95 N., R. 41 W.

A11—0 to 5 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky and granular structure; friable; neutral; gradual wavy boundary.

A12—5 to 11 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual wavy boundary.

A13—11 to 20 inches; black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual wavy boundary.

A14—20 to 30 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry, very dark gray (10YR 3/1) kneaded; weak medium subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual wavy boundary.

A15—30 to 42 inches; very dark gray (10YR 3/1) silty clay loam; few very fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure parting to weak very fine subangular blocky; friable; few very fine black segregations (oxides); neutral; gradual wavy boundary.

AC—42 to 58 inches; very dark gray (10YR 3/1) silty clay loam; few very fine distinct brown (7.5YR 4/4) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

C—58 to 60 inches; gray (5Y 5/1) and light olive gray (5Y 6/2) silty clay loam; few fine prominent brownish yellow (10YR 6/6 & 6/8) and reddish yellow (7.5YR 6/6 & 6/8) mottles; weak medium prismatic structure; friable; common dark gray (5Y 4/1) root channels in upper part; common fine black segregations (oxides); mildly alkaline.

The solum is 36 to 60 inches thick. Free carbonates commonly are at a depth of 36 to 60 inches. In some pedons there are no carbonates in the solum or within a depth of more than 60 inches. The mollic epipedon is 36 to more than 48 inches thick.

The A horizon has color value of 2 or 3 and chroma of 0 or 1. It is silty clay loam that consists of 27 to 35 percent clay. Below a depth of 24 inches, it commonly has mottles with value of 5 to 8 and chroma of 4 to 8.

The C horizon has value of 3 to 6 and chroma of 1 or 2. It commonly has mottles with value of 5 to 8 and chroma of 4 to 8.

Cylinder series

The Cylinder series consists of somewhat poorly drained, moderately permeable soils on stream benches. These soils formed in loamy or silty alluvium that is 24 to 40 inches thick over alluvial sandy and gravelly sediment. Slope ranges from 0 to 2 percent.

Cylinder soils are similar to Biscay and Fairhaven soils and commonly are adjacent on the landscape to Colo, Biscay, and Fairhaven soils. Colo soils have a mollic epipedon thicker than 36 inches, are poorly drained, and are on bottom lands below Cylinder soils. Biscay soils are poorly drained and are on stream benches below Cylinder soils. Fairhaven soils are well drained and are on stream benches above Cylinder soils.

Typical pedon of Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated field, 2,325 feet west and 125 feet north of the southeast corner of sec. 12, T. 97 N., R. 39 W.

Ap1—0 to 4 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; cloddy parting to weak very fine granular structure; friable; slightly acid; clear smooth boundary.

Ap2—4 to 8 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; cloddy parting to weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A13—8 to 13 inches; black (10YR 2/1) and very dark gray (10YR 3/1) loam; 20 percent dark grayish brown (2.5Y 4/2) peds in lower part; very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry, black (10YR 2/1) kneaded; weak fine granular structure parting to weak very fine granular; friable; neutral; gradual wavy boundary.

A3—13 to 19 inches; very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) clay loam, dark gray (10YR 4/1) and grayish brown (10YR 5/2) dry; 20 percent black (10YR 2/1) peds; very dark gray (10YR 3/1) kneaded; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; mildly alkaline; gradual wavy boundary.

B1—19 to 24 inches; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) clay loam; 20 percent very dark gray (2.5Y 3/1) and light olive brown (2.5Y 5/4) peds; dark grayish brown (2.5Y 4/2) kneaded; weak fine subangular blocky structure parting to weak very fine subangular blocky; friable; mildly alkaline; gradual wavy boundary.

B2—24 to 27 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) loam, grayish brown (2.5Y 5/2) kneaded; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few very dark gray (2.5Y 3/1) worm casts; mildly alkaline; gradual wavy boundary.

IIB3—27 to 31 inches; light olive brown (2.5Y 5/4) sandy loam, about 10 percent gravel; common fine faint dark grayish brown (2.5Y 4/2) mottles; very weak medium subangular blocky structure; very friable; mildly alkaline; clear wavy boundary.

IIC—31 to 60 inches; light olive brown (2.5Y 5/4) and light yellowish brown (2.5Y 6/4) gravelly sand and about 20 percent gravel; single grained loose; strong effervescence; moderately alkaline.

The solum is 24 to 40 inches thick. The underlying sand and gravel are at a depth of 24 to 40 inches. The mollic epipedon is 14 to 22 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is typically clay loam or silty clay loam but is loam in some pedons.

The B2 horizon has value of 4 or 5 and chroma of 2 to 4. It is loam, clay loam, silt loam, or silty clay loam. Reaction is neutral or mildly alkaline.

The IIC horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 to 6. It commonly is stratified sand that consists of 20 to 70 percent gravel but ranges to loamy sand that consists of less than 5 percent gravel. It ranges from a few to several feet in thickness.

Map unit 203 is a taxadjunct to the Cylinder series because the material above the sand and gravel is fine-silty rather than fine-loamy. This difference does not affect the use or behavior of the soil.

Estherville series

The Estherville series consists of somewhat excessively drained, moderately rapidly permeable soils on stream benches. These soils formed in loamy sediment underlain by sandy and gravelly sediment at a depth of 20 to 30 inches. Slope ranges from 1 to 14 percent.

Estherville soils are similar to Fairhaven soils and commonly are adjacent on the landscape to Colo, Galva, and Fairhaven soils. Colo soils formed in silty alluvium and are on bottom lands below Estherville soils. Galva soils formed in silty loess and are on uplands and stream benches above Estherville soils. Fairhaven soils formed in fine loamy and silty sediment underlain by sand and gravel at a depth of 24 to 40 inches and are on stream benches above Estherville soils.

Typical pedon of Estherville loam, 1 to 4 percent slopes, 505 feet west and 520 feet south of the northeast corner of sec. 22, T. 95 N., R. 39 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; cloddy parting to weak fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 13 inches; very dark gray (10YR 3/1) loam; about 20 percent black (10YR 2/1) peds; grayish brown (10YR 5/2) dry; weak medium subangular blocky structure parting to weak fine subangular blocky and granular; friable; slightly acid; gradual wavy boundary.

A3—13 to 18 inches; very dark grayish brown (10YR 3/2) sandy loam; about 40 percent dark brown (10YR 3/3) peds; brown (10YR 5/3) dry; few fine pebbles in lower part; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; slightly acid; gradual boundary.

B2—18 to 25 inches; brown (10YR 4/3) sandy loam, about 5 percent fine and medium gravel; weak fine and very fine subangular blocky structure; friable; slightly acid; clear wavy boundary.

IIB3—25 to 29 inches; yellowish brown (10YR 5/4) gravelly coarse loamy sand, about 30 percent gravel; faces of peds are dark yellowish brown (10YR 4/4); very weak very fine subangular blocky structure; very friable; very weak effervescence in lower part; neutral; clear wavy boundary.

IIC1—29 to 39 inches; yellowish brown (10YR 5/4) and light yellowish brown (10YR 6/4) gravelly coarse loamy sand, about 40 percent fine and medium gravel; single grained; loose; strong effervescence; moderately alkaline; clear wavy boundary.

IIC2—39 to 48 inches; yellowish brown (10YR 5/4) and light yellowish brown (10YR 6/4) gravelly coarse loamy sand, about 50 percent gravel; single grained; loose; strong effervescence; moderately alkaline; clear boundary.

IIC3—48 to 60 inches; yellowish brown (10YR 5/4) gravelly coarse loamy sand, about 70 percent gravel; single grained; loose; strong effervescence; moderately alkaline.

The solum is 20 to 30 inches thick. The IIC horizon is at a depth of 20 to 30 inches. The mollic epipedon is 10 to 18 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2.

The B2 horizon has value of 3 or 4 and chroma of 3 or 4. It is loam or sandy loam.

The colors of the B3 horizon and the B2 horizon are similar. The B3 horizon is sandy loam or loamy sand. The B horizon is neutral or slightly acid.

The IIC horizon has value of 4 or 5 and chroma of 3 to 5. It commonly is stratified sand and 20 to 70 percent gravel but includes layers that are less than 5 percent gravel.

Everly series

The Everly series consists of well drained, moderately permeable soils on uplands. These soils formed in 18 to 30 inches of loamy eolian sediment and in the underlying glacial till. Slope ranges from 5 to 14 percent.

Everly soils are similar to Sac soils and commonly are adjacent on the landscape to Galva, Sac, and Storden soils. Galva soils formed in loess, commonly are less sloping than Everly soils, and are above Everly soils. Sac soils formed in loess and in the underlying glacial till and are above Everly soils. Storden soils formed in glacial till, commonly have steeper slopes than Everly soils, and are below Everly soils on the landscape.

Typical pedon of Everly clay loam, 9 to 14 percent slopes, in a pasture 1,470 feet east and 2,610 feet south of the northwest corner of sec. 26, T. 94 N., R. 39 W.

A11—0 to 5 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; many very fine and micro roots; slightly acid; gradual smooth boundary.

A12—5 to 12 inches; black (10YR 2/1) clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; common very fine and micro roots; neutral; gradual wavy boundary.

B1—12 to 16 inches; very dark gray (10YR 3/1) clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; few micro roots; neutral; gradual wavy boundary.

B2—16 to 23 inches; brown (10YR 4/3) and very dark grayish brown (10YR 3/2) clay loam; few very dark gray (10YR 3/1) peds and ped exteriors in upper part; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; few micro roots; few very fine soft masses of lime; neutral; gradual wavy boundary.

IIB3—23 to 28 inches; brown (10YR 4/3) and light olive brown (2.5Y 5/4) clay loam; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; very few micro roots; strong effervescence; few very fine soft masses of lime; moderately alkaline; gradual wavy boundary.

IIC1—28 to 36 inches; light olive brown (2.5Y 5/4) and light yellowish brown (2.5Y 6/4) clay loam; few very fine distinct gray (10YR 6/1) and brownish yellow (10YR 6/6) mottles; weak medium subangular blocky and angular blocky structure; friable; very few micro roots; strong effervescence; few very fine soft masses of lime; moderately alkaline; gradual wavy boundary.

IIC2—36 to 48 inches; light olive brown (2.5Y 5/4) and light yellowish brown (2.5Y 6/4) clay loam; many fine and very fine distinct gray (10YR 6/1) and brownish yellow (10YR 6/6 & 6/8) mottles; weak medium angular blocky structure; friable; strong effervescence; few very fine soft masses of lime; moderately alkaline; gradual wavy boundary.

IIC3—48 to 60 inches; mottled gray (10YR 6/1), brownish yellow (10YR 6/6 & 6/8), and light yellowish brown (2.5Y 6/4) clay loam; few fine distinct yellowish red (5YR 5/8) mottles; massive; friable; strong effervescence; few very fine soft masses of lime; moderately alkaline.

The solum is 24 to 36 inches thick. The mollic epipedon is 12 to 18 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is loam or clay loam, but in a few pedons it is silty clay loam with enough sand to feel gritty.

The B2 horizon has value of 4 or 5 and chroma of 3 or 4. It is slightly acid or mildly alkaline loam or clay loam.

The IIC horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 3 or 4. It is loam or clay loam.

Fairhaven series

The Fairhaven series consists of well drained, moderately permeable soils on stream benches. These soils formed in loamy and silty sediment that is underlain by sandy and gravelly sediment at a depth of 24 to 40 inches. Slope ranges from 0 to 9 percent.

Fairhaven soils are similar to Estherville soils and commonly are adjacent on the landscape to Colo, Galva, and Estherville soils. Colo soils formed in silty alluvium and are on bottom lands below Fairhaven soils. Galva soils formed in silty loess and are on stream benches and uplands above Fairhaven soils. Estherville soils formed in loamy sediment that is underlain by sand and gravel at a depth of 20 to 30 inches. They are on stream benches below Fairhaven soils.

Typical pedon of Fairhaven silt loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes, 1,180 feet west and 275 feet south or the northeast corner of sec. 34, T. 96 N., R. 41 W.

Ap—0 to 8 inches; black (10YR 2/1) silt loam, dark grayish brown (10YR 4/2) dry; cloddy parting to weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A3—8 to 11 inches; dark brown (10YR 3/3) silty clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; common very dark brown (10YR 2/2) worm casts; neutral; clear wavy boundary.

B21—11 to 17 inches; yellowish brown (10YR 5/4) silty clay loam; faces of peds are brown (10YR 4/3); few very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) peds; weak very fine prismatic structure parting to weak very fine subangular blocky; friable; neutral; clear wavy boundary.

B22—17 to 23 inches; yellowish brown (10YR 5/4) light silty clay loam; faces of prisms are brown (10YR 4/3); weak fine prismatic structure parting to weak very fine subangular blocky; friable; neutral; gradual wavy boundary.

B23—23 to 29 inches; yellowish brown (10YR 5/4) silt loam (hue leans to 2.5Y); weak fine prismatic structure parting to weak very fine prismatic and subangular blocky; friable; neutral; clear wavy boundary.

B31—29 to 34 inches; light olive brown (2.5Y 5/3) silt loam; weak fine prismatic structure parting to weak very fine prismatic; friable; slight effervescence; common very fine and fine lime concretions and soft masses; moderately alkaline; abrupt wavy boundary.

B32—34 to 36 inches; light olive brown (2.5Y 5/3) loam, about 10 percent gravel; weak fine prismatic structure; friable; strong effervescence; common very fine and fine lime concretions and soft masses; some pebbles coated with lime; moderately alkaline; abrupt wavy boundary.

IIC1—36 to 39 inches; light olive brown (2.5Y 5/4) loamy sand, about 20 percent gravel; single grained; loose; strong effervescence; some pebbles coated with lime; moderately alkaline; abrupt wavy boundary.

IIC2—39 to 45 inches; light yellowish brown (2.5Y 6/4) gravelly loamy sand, about 30 percent gravel; single grained; loose; strong effervescence; moderately alkaline; clear wavy boundary.

IIC3—45 to 60 inches; light yellowish brown (2.5Y 6/4) gravelly sand, about 45 percent gravel; single grained; loose; strong effervescence; moderately alkaline.

The solum is 24 to 40 inches thick. The IIC horizon is at a depth of 24 to 40 inches. Free carbonates are at a depth of 20 to 48 inches. The mollic epipedon is 10 to 18 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 to 3.

The B2 horizon has value of 3 to 5 and chroma of 3 or 4. It is silty clay loam or silt loam that consists of 26 to 30 percent clay. Reaction is neutral or slightly acid.

The IIC horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 to 5. It commonly is stratified sand and 20 to 50 percent gravel, but it ranges to loamy sand and less than 5 percent gravel.

Galva series

The Galva series consists of well drained, moderately permeable soils on uplands and stream benches. These soils formed in loess. Slope ranges from 0 to 9 percent.

Galva soils are similar to Sac soils and commonly are adjacent on the landscape to Marcus, Primghar, and Sac soils. Marcus soils are poorly drained, and Primghar soils are somewhat poorly drained. They are in nearly level plane areas above Galva soils and in drainageways and on lower slopes below Galva soils. Sac soils have glacial till at a depth of less than 40 inches and typically have more convex or steeper slopes than the adjacent Galva soils.

Typical pedon of Galva silty clay loam, 2 to 5 percent slopes, in a cultivated field, 1,060 feet west and 190 feet south of the northeast corner of sec. 18, T. 94 N., R. 41 W.

Ap—0 to 6 inches; very dark brown (10YR 2/2) silty clay loam; dark grayish brown (10YR 4/2) dry; cloddy parting to weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A12—6 to 11 inches; very dark brown (10YR 2/2) and about 10 percent very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate fine granular and very fine subangular blocky structure; friable; slightly acid; clear wavy boundary.

B1—11 to 17 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; weak fine granular and very fine subangular blocky structure; friable; common very dark grayish brown (10YR 3/2) coatings on peds; neutral; gradual boundary.

B21—17 to 23 inches; brown (10YR 4/3) silty clay loam; weak medium subangular blocky structure parting to weak very fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) coatings on peds; neutral; gradual wavy boundary.

B22—23 to 31 inches; brown (10YR 4/3) silty clay loam; weak fine and medium subangular blocky structure parting to weak very fine subangular blocky; friable; neutral; gradual wavy boundary.

B3—31 to 45 inches; brown (10YR 4/3) silt loam, few fine distinct gray (10YR 5/1) mottles; weak fine and medium subangular blocky structure parting to weak very fine subangular blocky; friable; neutral; abrupt wavy boundary.

C—45 to 60 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct gray (10YR 5/1) and strong brown (7.5YR 5/6) mottles; weak fine and medium subangular blocky structure parting to weak very fine subangular blocky, massive in lower part; friable; few dark stains (oxides); strong effervescence; few fine lime concretions and soft masses; moderately alkaline.

The solum commonly is 36 to 48 inches thick. In areas where slopes are 0 to 2 percent and the underlying material is sandy or sandy skeletal, the solum commonly is more than 60 inches thick. The mollic epipedon is 10 to 17 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is silty clay loam that consists of 32 to 35 percent clay.

The B horizon has value of 3 to 5 and chroma of 3 or 4. The darker colors are in the upper part of the horizon. It is silt loam or silty clay loam that consists of 26 to 32 percent clay. Reaction is slightly acid to mildly alkaline.

The C horizon has value of 4 or 5 and chroma of 3 or 4. A IIC horizon is at a depth of 40 to 72 inches. It is loam or clay loam calcareous glacial till except on stream benches and in some upland areas, where it is gravelly loamy sand or gravelly sand.

Kennebec series

The Kennebec series consists of moderately well drained, moderately permeable soils on bottom lands. These soils formed in silty alluvium. Slope ranges from 0 to 2 percent. The Kennebec soils in the county are a taxadjunct to the Kennebec series. They have a mollic epipedon that is thinner than that in the defined range of the Kennebec series. They also have colors with higher chroma below the mollic epipedon than is defined for the Kennebec series and have free carbonates above a depth of 40 inches. These differences do not alter the use or behavior of the soils.

Kennebec soils are similar to Spillville soils and commonly are adjacent on the landscape to Terril soils. Terril soils are moderately well drained, have a higher sand content, and are on the lower part of side slopes and on alluvial fans above Kennebec soils. Spillville soils are somewhat poorly drained, have a loam texture, and commonly are on slightly lower landscape positions than Kennebec soils.

Typical pedon of Kennebec silty clay loam, 0 to 2 percent slopes, in a cultivated field, 2,000 feet east and 55 feet north of the southwest corner of sec. 27, T. 94 N., R. 39 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate very fine granular structure; friable; neutral; clear smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; slightly acid; clear wavy boundary.

A13—13 to 20 inches; black (10YR 2/1) and very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) dry; faces of peds are black (10YR 2/1); weak fine subangular blocky structure parting to weak fine and very fine granular; friable; slightly acid; gradual wavy boundary.

A14—20 to 26 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak very fine prismatic structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

AC1—26 to 31 inches; very dark grayish brown (10YR 3/2) silty clay loam; faces of peds are very dark brown (10YR 2/2); weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

AC2—31 to 38 inches; dark brown (10YR 3/3) silt loam; faces of peds are very dark grayish brown (10YR 3/2); weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

C1—38 to 44 inches; brown (10YR 4/3) silt loam leaning to dark grayish brown (10YR 4/2); faces of peds are very dark grayish brown (10YR 3/2); weak medium prismatic structure parting to weak fine subangular blocky; friable; strong effervescence; common very fine soft masses of lime; moderately alkaline; gradual wavy boundary.

C2—44 to 56 inches; dark grayish brown (10YR 4/2) silt loam; few fine distinct light brownish gray (10YR 6/

2) mottles; weak medium prismatic structure; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

C3—56 to 60 inches; dark grayish brown (10YR 4/2) and brown (10YR 5/3) silt loam; few fine distinct brownish yellow (10YR 6/6) mottles; massive; friable; few sand lenses and medium and coarse sand grains; strong effervescence; common fine soft masses of lime; moderately alkaline.

The solum is 30 to 48 inches thick. The mollic epipedon is more than 30 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes silt loam.

The AC horizon has value of 2 to 4 and chroma of 2 to 4. It is silt loam or silty clay loam that consists of 22 to 28 percent clay. Reaction is neutral to moderately alkaline.

The C horizon has value of 3 to 5 and chroma of 1 to 3.

Marcus series

The Marcus series consists of poorly drained, moderately slowly permeable soils in drainageways and in broad, nearly level areas on uplands. These soils formed in loess. Slope ranges from 0 to 2 percent.

Marcus soils are similar to Afton soils and commonly are adjacent on the landscape to Afton, Galva, and Primghar soils. Afton soils have a mollic epipedon thicker than 24 inches and are below the Marcus soils. Galva soils are well drained and are on ridgetops and side slopes above the Marcus soils. Primghar soils are somewhat poorly drained and are above the Marcus soils. In some places Primghar soils are in more convex or more sloping areas below the Marcus soils.

Typical pedon of Marcus silty clay loam, 0 to 2 percent slopes, 1,205 feet south and 125 feet west of the northeast corner of sec. 15, T. 96 N., R. 39 W.

Ap—0 to 7 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; cloddy parting to moderate very fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 12 inches; black (N 2/0) silty clay loam; few very dark gray (10YR 3/1) peds in the lower part; very dark gray (10YR 3/1) dry; moderate fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A3—12 to 16 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; faces of peds are black (10YR 2/1); weak very fine subangular blocky structure parting to moderate very fine granular; friable; slightly acid; gradual wavy boundary.

B1—16 to 20 inches; dark gray (2.5Y 4/1) silty clay loam, gray (10YR 5/1) dry; faces of peds are black (10YR 2/1); very dark gray (10YR 3/1) kneaded; few very fine reddish yellow (7.5YR 6/8) oxide stains; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; common fine black segregations (oxides); neutral; gradual wavy boundary.

B21—20 to 26 inches; olive gray (5Y 5/2) silty clay loam; faces of peds are black (10YR 2/1) and very dark gray (10YR 3/1); dark grayish brown (2.5Y 4/2) kneaded; common fine reddish yellow (7.5YR 6/8) oxide stains; weak fine subangular blocky structure parting to moderate very fine subangular blocky; friable; common fine black segregations (oxides); neutral; gradual wavy boundary.

B22—26 to 33 inches; olive gray (5Y 5/2) silty clay loam; faces of peds are dark gray (5Y 4/1); common fine prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak medium subangular blocky structure parting to moderate very fine subangular blocky; friable; common fine black segregations (oxides); neutral; gradual wavy boundary.

B23—33 to 40 inches; gray (5Y 5/1) silty clay loam; faces of peds are gray (2.5Y 5/1); common fine prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; common fine black segregations (oxides); neutral; gradual wavy boundary.

B3—40 to 48 inches; mottled light gray (2.5Y 6/1) and brownish yellow (10YR 6/6 & 6/8) silt loam; faces of prisms are light gray (2.5Y 6/1); weak fine prismatic structure; friable; common fine black segregations (oxides); strong effervescence; few fine lime concretions and soft masses; mildly alkaline; clear wavy boundary.

C1—48 to 59 inches; light gray (5Y 6/1) and light olive gray (5Y 6/2) silt loam; common fine and medium prominent brownish yellow (10YR 6/6 & 6/8) mottles; massive; friable; common fine black segregations (oxides); strong effervescence; few fine lime concretions and soft masses; moderately alkaline; clear wavy boundary.

IIC2—59 to 70 inches; light gray (5Y 6/1) and brownish yellow (10YR 6/6 & 6/8) loam; massive; friable; common fine black segregations (oxides); strong effervescence; few fine lime concretions and soft masses; moderately alkaline.

The solum is 30 to 54 inches thick. Free carbonates are at a depth of 24 to 48 inches. The mollic epipedon is 12 to 24 inches thick.

The A horizon has color value of 2 or 3 and chroma of 0 or 1. It is silty clay loam that consists of 32 to 38 percent clay.

The B2 horizon commonly has hue of 5Y but in some pedons has hue of 2.5Y. It has value of 4 or 5 and chroma of 1 to 3. It is silty clay loam but ranges to silt loam in the lower part in some pedons. Reaction is neutral or mildly alkaline.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 to 4. It is silt loam, but in most pedons below a depth of 40 to 60 inches it is loam or clay loam.

Ocheyedan series

The Ocheyedan series consists of well drained, moderately permeable soils on uplands. These soils formed in loamy and silty glacial and aeolian sediment. Slope ranges from 2 to 5 percent.

Ocheydan soils are similar to Bolan soils and commonly are adjacent on the landscape to Bolan and Galva soils. Bolan soils are less than 18 percent clay between depths of 10 and 40 inches and commonly are on slopes below Ocheyedan soils. Galva soils formed in loess and are above Ocheyedan soils on the landscape.

Typical pedon of Ocheyedan loam, 2 to 5 percent slopes, in a cultivated field, 2,165 feet east and 130 feet south of the northwest corner of sec. 16, T. 95 N., R. 41 W.

Ap—0 to 7 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; cloddy parting to weak fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A12—7 to 12 inches; very dark brown (10YR 2/2) and very dark gray (10YR 3/1) loam, dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) dry; very dark brown (10YR 2/2) kneaded; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; common black (10YR 2/1) worm casts and root channels; slightly acid; gradual wavy boundary.

A3—12 to 16 inches; very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) loam, grayish brown (10YR 5/2) and brown (10YR 5/3) dry; very dark grayish brown (10YR 3/2) kneaded; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; few black (10YR 2/1) worm casts and root channels; slightly acid; gradual wavy boundary.

B1—16 to 21 inches; brown (10YR 4/3) and very dark grayish brown (10YR 3/2) loam, brown (10YR 4/3) kneaded; weak fine subangular blocky structure parting to weak very fine subangular blocky; friable; few black (10YR 2/1) worm casts and root channels; slightly acid; gradual wavy boundary.

B21—21 to 29 inches; yellowish brown (10YR 5/4) loam; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; few very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) worm casts; thin patchy brown (10YR 4/3) coatings; neutral; clear wavy boundary.

B22—29 to 34 inches; yellowish brown (10YR 5/4) sandy clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thin patchy brown (10YR 4/3) coatings; neutral; clear wavy boundary.

IIB23—34 to 48 inches; yellowish brown (10YR 5/4) and light olive brown (2.5Y 5/4) silt loam; few very fine distinct brownish yellow (10YR 6/8) and light brownish gray (2.5Y 6/2) mottles; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; thin brown (2.5Y 5/3) coatings; few very fine black segregations (oxides); neutral; gradual wavy boundary.

IIB3—48 to 60 inches; light olive brown (2.5Y 5/4) silt loam; few fine distinct brownish yellow (10YR 6/8) and light brownish gray (2.5Y 6/2) mottles; weak medium prismatic structure; friable; few thin brown (2.5Y 4/3) coatings; neutral.

The mollic epipedon is 10 to 16 inches thick. Between depth of 10 and 40 inches the clay content is more than 18 percent.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is loam that consists of 18 to 26 percent clay.

The B2 horizon has value of 4 or 5 and chroma of 4. It commonly is loam, but most pedons have B2 subhorizons that range from sandy loam to sandy clay loam. Reaction is neutral or slightly acid.

The C horizon, where present, has hue of 10YR and, less commonly, 2.5Y. Value is 4 or 5 and chroma is 4 to 6. The C horizon is silt loam in most pedons, but it ranges to loam and sandy loam.

Primghar series

The Primghar series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in loess. Slope ranges from 0 to 4 percent.

Primghar soils are similar to Ransom soils and commonly are adjacent on the landscape to Galva, Marcus, and Ransom soils. Galva soils are well drained and commonly are on convex ridgetops and side slopes above Primghar soils. Marcus soils are poorly drained and commonly are on upland divides and in drainageways below Primghar soils. Ransom soils have loam or clay loam glacial till at a depth of 24 to 40 inches. They are commonly on convex slopes above Primghar soils.

Typical pedon of Primghar silty clay loam, 0 to 2 percent slopes, in a cultivated field, 1,770 feet west and 480 feet north of the southeast corner of sec. 34, T. 97 N., R. 40 W.

Ap—0 to 6 inches; black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) dry; weak fine granular and weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A12—6 to 11 inches; black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) dry; moderate fine granular structure; friable; medium acid; gradual wavy boundary.

A3—11 to 17 inches; very dark brown (10YR 2/2) silty clay loam; dark grayish brown (10YR 4/2) dry; some

mixing of very dark grayish brown (10YR 3/2 & 2.5Y 3/2) peds in lower part; moderate fine subangular blocky and medium granular structure; friable; few fine dark segregations (oxides); medium acid; gradual wavy boundary.

B21—17 to 25 inches; dark grayish brown (10YR 4/2) silty clay loam; moderate fine subangular blocky structure; friable; many narrow, very dark gray (10YR 3/1) streaks, worm casts, and root channels; many fine dark segregations (oxides); many fine and a few tubular pores; slightly acid; gradual wavy boundary.

B22—25 to 35 inches; olive brown (2.5Y 4/3) silty clay loam; many very fine faint brown (10YR 5/3) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; many dark segregations (oxides); many fine and very fine tubular pores; mildy alkaline; gradual wavy boundary.

B3—35 to 44 inches; light olive brown (2.5Y 5/4) silt loam; common fine faint grayish brown (2.5Y 5/2) and very fine brown (10YR 5/3) mottles; weak coarse prismatic structure parting to very weak subangular blocky; friable; many dark segregations (oxides); many fine and a few medium tubular pores; strong effervescence; common medium lime concretions; moderately alkaline; clear wavy boundary.

IIC1—44 to 49 inches; light olive brown (2.5Y 5/4) gravelly loam; common fine faint grayish brown (2.5Y 5/2) mottles; massive; friable; common fine and medium tubular pores; pebble band with material 3/4 to 3 inches in diameter; strong effervescence; most pebbles have lime coatings on lower surfaces; moderately alkaline; clear wavy boundary.

IIC2—49 to 60 inches; yellowish brown (10YR 5/4) clay loam; common fine distinct grayish brown (2.5Y 5/2) mottles mostly associated with common very fine to medium tubular pores; massive; firm; strong effervescence; few lime concretions; some pebbles and stones; moderately alkaline.

The solum is 30 to 50 inches thick. Free carbonates are at a depth of 24 to 50 inches. The mollic epipedon is 16 to 24 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is silty clay loam that consists of 32 to 36 percent clay.

The B2 horizon, in the upper part, has hue of 2.5Y or 10YR, value of 4, and chroma of 2, or it has value of 4 and chroma of 3 with mottles that have value of 4 or more and chroma of 2 or less. Color value of the B2 horizon commonly increases with depth to 5, and chroma increases to 3 or 4. This horizon is silty clay loam, but in the lower part in some pedons it is silt loam. Reaction is slightly acid to mildly alkaline.

The C horizon has color value of 4 or 5 and chroma of 3 to 6. It is silt loam in the upper part in some pedons and loam or clay loam throughout in others. In some pedons there is as much as 6 inches of sandy or gravelly material between the silt loam loess and the loam or clay loam glacial till.

Ransom series

The Ransom series consists of somewhat poorly drained, moderately slowly permeable soils on uplands. These soils formed in loess that is underlain by glacial till at a depth of 24 to 40 inches. Slope ranges from 1 to 3 percent.

Ransom soils are similar to Primghar soils and commonly are adjacent on the landscape to Galva, Marcus, and Primghar soils. Galva, Marcus, and Primghar soils formed in loess that is more than 40 inches thick. Galva soils are well drained and are more sloping than the Ransom soils. Marcus soils are poorly drained and commonly are on upland divides and on drainageways below Ransom soils. Primghar soils typically have less convex slopes and are below Ransom soils on the landscape.

Typical pedon of Ransom silty clay loam, 1 to 3 percent slopes, in a cultivated field, 1,230 feet east and 1,155 feet north of the southwest corner of sec. 12, T. 95 N., R. 39 W.

Ap—0 to 6 inches; black (10YR 2/1) silty clay loam; dark grayish brown (10YR 4/2) dry; cloddy, parting to weak fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A12—6 to 10 inches; black (10YR 2/1) silty clay loam; dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; slightly acid; gradual smooth boundary.

A3—10 to 14 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; gradual wavy boundary.

B1—14 to 17 inches; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) silty clay loam; dark grayish brown (2.5Y 4/2) kneaded; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

B2—17 to 21 inches; dark grayish brown (2.5Y 4/2) and brown (2.5Y 5/3) silty clay loam; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

B3—21 to 28 inches; light brownish gray (2.5Y 6/2) and light yellowish brown (2.5Y 6/4) silt loam; few fine distinct brownish yellow (10YR 6/6 & 6/8) mottles; weak medium prismatic structure; friable; few fine black segregations (oxides); strong effervescence; common fine and medium lime concretions and soft masses; mildly alkaline; gradual wavy boundary.

IIC1—28 to 42 inches; brownish yellow (10YR 6/6) loam; few fine distinct gray (10YR 6/1) mottles; massive;

friable; strong effervescence; few fine and medium lime concretions and soft masses; sand layer about 2 inches thick; moderately alkaline; gradual wavy boundary.

IIC2—42 to 60 inches; yellowish brown (10YR 5/4) loam; many fine and medium distinct brownish yellow (10YR 6/6) and few fine distinct gray (10YR 6/1) mottles; massive; friable; strong effervescence; few fine soft lime masses; moderately alkaline.

The solum is 26 to 40 inches thick. Free carbonates are at a depth of 22 to 36 inches. The mollic epipedon is 14 to 20 inches thick. Glacial till is at a depth of 24 to 40 inches.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is silty clay loam that consists of 32 to 36 percent clay.

The B horizon in the upper part has hue of 2.5Y or 10YR, value of 4, and chroma of 1 or 2, or value of 4 and chroma of 3 with mottles that have value of 4 or more and chroma of 2 or less. The value of the B2 horizon commonly increases with depth to 5 or 6, and chroma increases to 3 or 4. This horizon is silty clay loam or silt loam. Reaction is neutral or mildly alkaline.

The IIC horizon has value of 5 or 6 and chroma of 2 to 6. It is loam or clay loam. In some pedons there are sandy or gravelly layers as much as 6 inches thick between the silt loam loess and the loam or clay loam glacial till.

Sac series

The Sac series consists of well drained, moderately permeable soils on uplands. These soils formed in loess and the underlying glacial till. Slope ranges from 2 to 9 percent.

Sac soils are similar to Galva soils and commonly are adjacent on the landscape to Galva, Marcus, and Primghar soils. Galva, Marcus, and Primghar soils formed in loess that is thicker than 40 inches. Marcus soils are poorly drained, and Primghar soils are somewhat poorly drained. They are below Sac soils on the landscape.

Typical pedon of Sac silty clay loam, 2 to 5 percent slopes, 1,790 feet east and 55 feet south of the northwest corner of sec. 16, T. 97 N., R. 41 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam; dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A3—7 to 12 inches; dark brown (10YR 3/3) and very dark brown (10YR 2/2) silty clay loam, brown (10YR 4/3) and yellowish brown (10YR 5/4) dry; dark brown (10YR 3/3) kneaded; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; clear wavy boundary.

B21—12 to 18 inches; brown (10YR 4/3) silty clay loam; faces of peds are dark brown (10YR 3/3); brown (10YR 4/3) kneaded; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) worm casts; neutral; gradual wavy boundary.

B22—18 to 25 inches; yellowish brown (10YR 5/4) silty clay loam; faces of peds are brown (10YR 4/3); brown (10YR 5/3) kneaded; weak medium prismatic structure parting to weak fine subangular blocky; friable; mildly alkaline; gradual wavy boundary.

B23—25 to 31 inches; yellowish brown (10YR 5/4) silt loam; faces of peds are brown (10YR 4/3); weak medium prismatic structure parting to weak fine prismatic; friable; mildly alkaline; clear wavy boundary.

IIB3—31 to 36 inches; yellowish brown (10YR 5/4) loam; weak medium prismatic structure; friable; strong effervescence; few fine and medium lime concretions and soft masses; moderately alkaline; gradual smooth boundary.

IIC—36 to 60 inches; light olive brown (2.5Y 5/4) clay loam; massive; firm; strong effervescence; few fine lime concretions and soft masses; moderately alkaline.

The solum is 30 to 48 inches thick. Free carbonates are in the lower part of the B horizon in many pedons. The mollic epipedon is 10 to 16 inches thick. Glacial till is at a depth of 24 to 40 inches.

The A horizon has color value of 2 or 3 and chroma of 2 or 3.

The B2 horizon has value of 4 to 6 and chroma of 3 or 4. It is silty clay loam except in most pedons with glacial till at more than 30 inches where the lower part of the B2 horizon is silt loam. Reaction is neutral or mildly alkaline but includes moderately alkaline in the lower part.

The IIC horizon has value of 5 or 6 and chroma of 3 or 4 but commonly has mottles of high and low chroma colors. It is loam or clay loam.

Sac Variant

The Sac Variant consists of well drained, moderately permeable soils on uplands. These soils formed in loess and in the underlying silty glacial drift. Slope ranges from 2 to 9 percent.

Sac Variant soils are similar to Sac soils and commonly are adjacent on the landscape to Galva and Primghar soils. Sac soils formed in loess and in loamy glacial till. Galva and Primghar soils formed in loess that is thicker than 40 inches and are typically below Sac Variant soils. In addition, Primghar soils are somewhat poorly drained.

Typical pedon of Sac Variant silty clay loam, 2 to 5 percent slopes, 465 feet south and 140 feet east of the northwest corner of sec. 25, T. 96 N., R. 42 W.

Ap—0 to 7 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) silty clay loam, dark

grayish brown (10YR 4/2) dry; very dark grayish brown (10YR 3/2) kneaded; cloddy parting to weak very fine granular structure; friable; medium acid; clear smooth boundary.

A3—7 to 11 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry; faces of peds are black (10YR 2/1); moderate fine and very fine subangular blocky and granular structure; friable; slightly acid; gradual smooth boundary.

B21—11 to 17 inches; brown (10YR 4/3) silty clay loam, light yellowish brown (10YR 6/4) dry; faces of peds are very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3); weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) worm casts; neutral; gradual wavy boundary.

B22—17 to 23 inches; yellowish brown (10YR 5/4) silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear wavy boundary.

B3—23 to 28 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct gray (2.5Y 6/1) mottles; weak medium prismatic structure; friable; few fine and medium lime concretions and soft masses; mildly alkaline; gradual wavy boundary.

C1—28 to 33 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct gray (2.5Y 6/1) and brownish yellow (10YR 6/8) mottles; weak coarse prismatic structure; friable; common very fine black segregations (oxides); strong effervescence; few very fine lime concretions and soft masses; moderately alkaline; clear wavy boundary.

IIC2—33 to 48 inches; light brownish gray (2.5Y 6/2) silt loam with a few coarse sand and fine pebbles; few fine prominent brownish yellow (10YR 6/8) mottles; massive; friable; few medium yellowish red (5YR 5/8) and few fine black segregations (oxides); strong effervescence; common very fine soft lime masses; moderately alkaline; diffuse wavy boundary.

IIC3—48 to 60 inches; light brownish gray (2.5Y 6/2) silt loam with a few coarse sand and fine pebbles; common very fine and fine prominent brownish yellow (10YR 6/8) mottles; massive; friable; few fine and medium yellowish red (5YR 5/8) and few fine black segregations (oxides); strong effervescence; common very fine soft lime masses; moderately alkaline.

The solum is 20 to 40 inches thick. Free carbonates are at a depth of 20 to 40 inches. The IIB or IIC horizon is at a depth of 24 to 40 inches. The mollic epipedon is 10 to 15 inches thick.

The A horizon has color value of 2 or 3 (4 or 5 dry) and chroma of 1 to 3.

The B2 horizon has value of 4 to 6 and chroma of 3 to 5. It is silty clay loam except in some pedons with glacial drift at a depth of more than 30 inches where it is silt loam in the lower part. Reaction ranges from slightly acid to mildly alkaline.

The IIC horizon has value of 5 or 6 and chroma of 1 or 2 and commonly has mottles of high chroma colors. It is silt loam or silty clay loam. Less commonly it is clay loam in which the content of sand is 15 to 25 percent. In some pedons the B2 horizon in the lower part has these colors and textures.

Salida series

The Salida series consists of excessively drained, very rapidly permeable soils on upland ridgetops and upper hillsides, on lower side slopes adjacent to streams, and on terrace edges. They formed in gravelly, loamy, and sandy textured glacial deposits. Slope ranges from 9 to 40 percent. Salida soils in the county are a taxadjunct to the Salida series. These soils have less gravel in the solum than that in the defined range of the Salida series. This difference does not alter the use or behavior of the soils.

Salida soils are not similar to any other soils in the county. They commonly are adjacent to Colo, Galva, and Storden soils. Colo soils formed in silty alluvium and are on bottom lands below Salida soils. Galva soils formed in silty loess and are on uplands and terraces above Salida soils. Storden soils formed in loamy glacial till and are on side slopes below Salida soils.

Typical pedon of Salida sandy loam, 9 to 18 percent slopes, in a pasture, 2,395 feet west and 260 feet south of the northeast corner of sec. 9, T. 96 N., R. 41 W.

A11—0 to 6 inches; very dark brown (10YR 2/2) sandy loam with about 10 percent gravel; dark grayish brown (10YR 4/2) dry; weak fine granular structure; very friable; slight effervescence; moderately alkaline; clear wavy boundary.

A12—6 to 9 inches; very dark grayish brown (10YR 3/2) gravelly sandy loam; brown (10YR 5/3) dry; single grained; loose; strong effervescence; lime coatings and cemented fine earth and fine gravel on undersides of gravel; moderately alkaline; clear wavy boundary.

B2—9 to 12 inches; brown (10YR 4/3) gravelly loamy sand; single grained; loose; strong effervescence; lime coatings and cemented fine earth and fine gravel on undersides of gravel; moderately alkaline; gradual wavy boundary.

C—12 to 60 inches; stratified yellowish brown (10YR 5/6 & 5/8), brown (10YR 4/3), and strong brown (7.5YR 5/8) gravelly loamy sand and sand; single grained; loose; strong effervescence; lime coatings on undersides of gravel in upper 12 inches; moderately alkaline.

In most pedons free carbonates are at the surface, but in some pedons they range to 12 inches. The mollic epipedon is 7 to 10 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is dominantly sandy loam or gravelly sandy loam but the range includes loamy sand and gravelly loamy sand.

The B2 horizon has value of 3 or 4 and chroma of 2 to 4, and the darker colors are in the upper part. This horizon is gravelly loamy sand or sand, but in some pedons it is less than 15 percent gravel. There are lime coatings on the underside of gravel, and in many places there are fine earth and fine gravel cemented to the underside of coarse gravel. Reaction is moderately alkaline except some pedons are mildly alkaline in the upper part.

The C horizon has value of 3 to 6 and chroma of 3 to 6. In some pedons there are lime coatings on the undersides of gravel in the upper part of the horizon.

Sperry series

The Sperry series consists of very poorly drained, moderately slowly permeable soils in depressions on uplands. These soils formed in loess. Slope ranges from 0 to 1 percent. The Sperry soils in the county are a taxadjunct to the Sperry series. These soils do not have the abrupt textural change from the A to the B horizon that is definitive for the Sperry series, and carbonates are at a depth of less than 60 inches. These differences do not alter the use or behavior of the soils.

Sperry soils are not similar to any other soils in the county. They are adjacent to Galva, Marcus, and Primghar soils. Galva, Marcus, and Primghar soils have less clay in the B horizon and are above Sperry soils on the landscape.

Typical pedon of Sperry silty clay loam, 0 to 1 percent slopes, 315 feet south and 160 feet west of the center of sec. 32, T. 95 N., R. 42 W.

A1—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak medium platy structure parting to weak fine and very fine granular; friable; slightly acid; clear smooth boundary.

A21—7 to 12 inches; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; common fine distinct olive brown (2.5Y 4/4) stains; weak medium platy structure parting to weak thin and very thin platy; friable; gray (10YR 6/1) dry silt coatings; slightly acid; abrupt wavy boundary.

A22—12 to 15 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; faces of peds are black (10YR 2/1); common fine distinct dark yellowish brown (10YR 4/4) and olive brown (2.5Y 4/4) stains; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; slightly acid; abrupt wavy boundary.

B21—15 to 21 inches; dark grayish brown (2.5Y 4/2) silty clay; many fine and very fine prominent yellowish brown (10YR 5/6) and brownish yellow (10YR 6/6) mottles; weak fine prismatic structure parting to strong fine and very fine subangular blocky; firm; continuous thin black (10YR 2/1) clay films on faces of peds; slightly acid; gradual wavy boundary.

B22—21 to 27 inches; dark grayish brown (2.5Y 4/2) silty clay; many fine and very fine prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak fine prismatic structure parting to strong fine and very fine subangular blocky; firm; continuous thin very dark gray (10YR 3/1) and dark gray (10YR 4/1) clay films on faces of peds; common fine black segregations (oxides); slightly acid; gradual wavy boundary.

B23g—27 to 34 inches; olive gray (5Y 5/2) silty clay; many fine and very fine distinct light yellowish brown (2.5Y 6/4) and prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak fine prismatic structure parting to moderate very fine prismatic and subangular blocky; firm; continuous thin dark gray (5Y 4/1) clay films on faces of peds; common fine black segregations (oxides); neutral; gradual wavy boundary.

B24g—34 to 42 inches; mottled olive (5Y 5/3), gray (10YR 6/1), and brownish yellow (10YR 6/6 & 6/8) silty clay loam; weak fine prismatic structure parting to moderate very fine prismatic and subangular blocky; friable; common thin gray (5Y 5/1) and olive gray (5Y 5/2) clay films on faces of peds; common fine black segregations (oxides); mildly alkaline; gradual wavy boundary.

B25g—42 to 50 inches; olive gray (5Y 5/2) silty clay loam; many fine and medium faint gray (10YR 6/1) and prominent brownish yellow (10YR 6/6 & 6/8) mottles; weak fine prismatic structure parting to weak very fine prismatic; friable; few thin clay films on faces of peds; common fine black segregations (oxides); mildly alkaline; clear wavy boundary.

B3g—50 to 60 inches; olive gray (5Y 5/2) and gray (5Y 5/1) silty clay loam; common fine prominent brownish yellow (10YR 6/6 & 6/8) and reddish yellow (7.5YR 6/6 & 6/8) mottles; weak fine and medium prismatic structure; friable; common fine black segregations (oxides); strong effervescence; common very fine soft lime masses; moderately alkaline.

The solum is 40 to 65 inches thick. In most pedons free carbonates are at a depth of 48 to 60 inches. The mollic epipedon is 10 to 20 inches thick.

The A1 horizon has color value of 2 or 3 and chroma of 0 to 2. It is dominantly silty clay loam but the range includes silt loam. The A2 horizon has value of 2 to 4 and chroma of 1 or 2. It is silt loam except in some pedons where the lower part is silty clay loam.

The B2 horizon has value of 4 to 6 and chroma of 1 or 2 except for higher chroma in pedons where the horizon is mottled. It is silty clay and silty clay loam, but the range includes silt loam in the lower part. It averages

about 36 to 42 percent clay. Reaction is medium acid to neutral, but the range includes mildly alkaline in the lower part.

The C horizon has colors like those in the B2 horizon. It is neutral to moderately alkaline.

Spicer series

The Spicer series consists of poorly drained, moderately permeable soils in drainageways and in broad, nearly level areas on uplands. These soils formed in calcareous loess. Slope ranges from 0 to 2 percent.

Spicer soils are similar to Marcus soils and commonly are adjacent on the landscape to Afton, Marcus, and Primghar soils. Afton, Marcus, and Primghar soils lack free carbonates in the upper solum. Afton soils have a mollic epipedon more than 24 inches thick and are in drainageways below Spicer soils. Marcus soils are in similar positions on the landscape. Primghar soils are somewhat poorly drained and are in drainageways and in nearly level areas above Spicer soils.

Typical pedon of Spicer silty clay loam, 0 to 2 percent slopes, 1,480 feet east and 135 feet north of the southwest corner of sec. 22, T. 97 N., R. 42 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; cloddy parting to moderate fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

A3—13 to 19 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) and grayish brown (2.5Y 5/2) dry; few dark grayish brown (2.5Y 4/2) peds in lower part; weak fine subangular blocky structure parting to weak very fine granular; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

B1g—19 to 24 inches; dark gray (2.5Y 4/1) and very dark gray (2.5Y 3/1) silty clay loam, dark gray (2.5Y 4/1) kneaded; common fine faint grayish brown (2.5Y 5/2), common fine distinct light olive brown (2.5Y 5/4), and few very fine prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; common very fine black segregations (oxides); strong effervescence; moderately alkaline; gradual wavy boundary.

B2g—24 to 30 inches; olive gray (5Y 5/2) silty clay loam; faces of peds are very dark gray (2.4Y 3/1) and dark grayish brown (2.5Y 4/2); grayish brown (2.5Y 5/2) kneaded; few very fine distinct brownish yellow (10YR 6/8) and few very fine prominent strong brown (7.5YR 5/8) mottles; weak medium subangular blocky structure parting to weak fine subangular blocky and granular; friable; common very fine black segregations (oxides); strong effervescence; few very fine soft masses of lime; moderately alkaline; gradual wavy boundary.

B3g—30 to 38 inches; olive gray (5Y 5/2) silty clay loam; common fine prominent brownish yellow (10YR 6/8) and strong brown (7.5YR 5/8) and common fine distinct gray (2.5Y 6/1) mottles; weak medium subangular blocky structure; friable; few fine dark gray (2.5Y 4/1) channels; common very fine black segregations (oxides); strong effervescence; common very fine lime concretions and soft masses; moderately alkaline; gradual wavy boundary.

C—38 to 60 inches; gray (2.5Y 6/1) silt loam; many fine and medium prominent brownish yellow (10YR 6/6 & 6/8) mottles; massive; friable; common very fine black segregations (oxides); strong effervescence; common fine lime concretions and soft masses; moderately alkaline.

The solum is 24 to 48 inches thick. Free carbonates are throughout the solum, but in some pedons there are none in the lower B horizon. The mollic epipedon is 12 to 24 inches thick.

The A horizon has color value of 2 or 3 and chroma of 0 or 1. It is silty clay loam and 30 to 35 percent clay.

The B2 horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is silty clay loam but ranges to silt loam in some pedons. Reaction is mildly or moderately alkaline.

The C horizon has value of 5 or 6 and chroma of 1 or 2. It commonly is silt loam, but in some pedons it is loam or clay loam below a depth of 40 inches.

Spillco series

The Spillco series consists of somewhat poorly drained, moderately permeable soils on stream bottom lands. These soils formed in calcareous loamy alluvium. Slope ranges from 0 to 2 percent.

Spillco soils are similar to Spillville soils and commonly are adjacent on the landscape to Colo and Spillville soils. Colo soils formed in silty alluvium, are poorly drained, and are below Spillco soils. Spillville soils formed in loamy alluvium, are noncalcareous throughout, and are above or are farther from the stream channel than Spillco soils.

Typical pedon of Spillco loam, 0 to 2 percent slopes, 1,595 feet west and 180 feet south of the northeast corner of sec. 4, T. 95 N., R. 39 W.

A11—0 to 6 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A12—6 to 12 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak medium granular structure parting to weak fine and very fine granular; friable; neutral; gradual wavy boundary.

A13—12 to 18 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; clear wavy boundary.

A14—18 to 26 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; few fine gravel; slight effervescence; mildly alkaline; gradual wavy boundary.

A15—26 to 36 inches; very dark brown (10YR 2/2) loam; weak fine and medium subangular blocky structure parting to weak very fine subangular blocky; friable; few fine gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

AC—36 to 42 inches; very dark grayish brown (2.5Y 3/2) loam; weak fine prismatic structure parting to weak very fine subangular blocky; friable; few fine gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

C—42 to 60 inches; dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2) sandy loam; massive; very friable; 1 inch fine and medium gravel layer at 46 inches; strong effervescence; moderately alkaline.

The solum is 30 to 48 inches thick. Free carbonates are at a depth of 15 to 36 inches. The mollic epipedon is 30 to more than 48 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is dominantly loam but ranges to silt loam that consists of more than 15 percent sand that is coarser than very fine sand. In some pedons part of this horizon is light clay loam.

The C horizon has value of 3 or 4 and chroma of 2. Some pedons have an AC horizon with color value of 3 and chroma of 1. The C horizon is sandy loam, loam, or silt loam.

Spillville series

The Spillville series consists of somewhat poorly drained, moderately permeable soils on stream bottom lands. These soils formed in loamy alluvium. Slope ranges from 0 to 2 percent.

Spillville soils are similar to Spillco soils and commonly are adjacent on the landscape to Colo and Spillco soils. Colo soils formed in silty alluvium, are poorly drained, and are below Spillville soils. Spillco soils have free carbonates in the solum and commonly are below Spillville soils on the landscape.

Typical pedon of Spillville loam, 0 to 2 percent slopes, 625 feet north and 160 feet east of the southwest corner of sec. 34, T. 95 N., R. 41 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A12—8 to 14 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky and granular structure; friable; neutral; gradual smooth boundary.

A13—14 to 20 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual wavy boundary.

A14—20 to 28 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; few very dark gray (10YR 3/1) peds; weak fine subangular blocky structure parting to weak very fine subangular blocky; friable; neutral; gradual smooth boundary.

A15—28 to 36 inches; very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) light sandy clay loam; few black (10YR 2/1) peds; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

AC—36 to 48 inches; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) heavy sandy loam; 20 percent very dark gray (10YR 3/1) in upper part; very dark grayish brown (2.5Y 3/2) kneaded; few fine distinct brownish yellow (10YR 6/6 & 6/8) stains in lower part; weak medium subangular blocky structure; friable; neutral; clear wavy boundary.

C—48 to 60 inches; dark grayish brown (2.5Y 4/2) heavy sandy loam, few very fine distinct brownish yellow (10YR 6/6 & 6/8) stains; massive; friable; strong effervescence; common very fine soft lime masses; moderately alkaline.

The solum is 36 to 54 inches thick. Free carbonates are at a depth of 48 to 60 inches. The mollic epipedon is 36 to more than 48 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2. It is dominantly loam, but the range includes silt loam, heavy sandy loam, and light sandy clay loam in the lower part.

The C horizon has value of 3 or 4 and chroma of 2. Some pedons have an AC horizon with color value of 3 and chroma of 1. The C horizon is sandy loam, loam, or silt loam.

Storden series

The Storden series consists of well drained, moderately permeable soils on uplands. These soils formed in calcareous glacial till. Slope ranges from 9 to 40 percent. The Storden soils in the county are taxadjuncts to the Storden series. They have a mollic A horizon. This difference from the defined range of the Storden series does not affect the use or behavior of the soils.

Storden soils are similar to Everly soils and commonly are adjacent on the landscape to Galva and Terril soils. Everly soils formed in loamy sediment, have a B horizon,

and are on ridgetops above Storden soils. Galva soils formed in loess on ridges and side slopes. Terril soils formed in loamy local alluvium, have a cambic horizon, and are on foot slopes and alluvial fans below Storden soils.

Typical pedon of Storden loam, 25 to 40 percent slopes, 1,035 feet west and 625 feet north of the center of sec. 27, T. 94 N., R. 39 W.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) loam; grayish brown (10YR 5/2) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear wavy boundary.

AC1—4 to 7 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) loam, yellowish brown (10YR 5/4) dry; faces of peds are very dark grayish brown (10YR 3/2), dark grayish brown (10YR 4/2) kneaded; weak fine subangular blocky structure parting to weak fine and very fine granular; strong effervescence; moderately alkaline; clear wavy boundary.

AC2—7 to 12 inches; brown (10YR 5/3) and yellowish brown (10YR 5/4) loam; faces of peds are dark brown (10YR 4/3); a few very dark grayish brown (10YR 3/2) peds; weak medium subangular blocky structure parting to weak fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) worm casts and root channels; strong effervescence; moderately alkaline; gradual wavy boundary.

C1—12 to 24 inches; yellowish brown (10YR 5/4) clay loam; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; firm; few fine and medium strong brown (7.5YR 5/8) segregations (oxides); strong effervescence; few very fine lime concretions and soft masses; moderately alkaline; diffuse wavy boundary.

C2—24 to 36 inches; yellowish brown (10YR 5/4) clay loam; few fine distinct brownish yellow (10YR 6/6) mottles; massive; firm; few fine and medium strong brown (7.5YR 5/8) and yellowish red (5YR 5/8) segregations (oxides); strong effervescence; fine irregular lime concretions and soft masses; moderately alkaline; diffuse wavy boundary.

C3—36 to 60 inches; light yellowish brown (2.4Y 6/4) and light olive brown (2.5Y 5/4) clay loam; few fine distinct brownish yellow (10YR 6/6) mottles; massive; firm; few fine and medium strong brown (7.5YR 5/8) and yellowish red (5YR 5/8) segregations (oxides); strong effervescence; fine and medium irregular lime seams; moderately alkaline; diffuse wavy boundary.

The solum is 8 to 20 inches thick. Free carbonates commonly are at the surface but also range to a depth of about 14 inches. Colors with a value of more than 3.5 moist are at a depth of 3 to 6 inches.

The A horizon has color value of 2 or 3 and chroma of 2. It commonly is loam, but the range includes clay loam.

The AC horizon has value of 3 to 5 and chroma of 2 to 4 with the darker colors in the upper part. It is loam or clay loam.

The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4.

Terril series

The Terril series consists of moderately well drained, moderately permeable soils on foot slopes and alluvial fans. These soils formed in loamy local alluvium. Slope ranges from 2 to 14 percent.

Terril soils are similar to Everly soils and commonly are adjacent on the landscape to Colo, Spillco, and Storden soils. Colo and Spillco soils formed in alluvium on bottom lands below Terril soils. Everly soils have a mollic epipedon thinner than 20 inches and formed in eolian material over glacial till on uplands. Storden soils lack a B horizon, formed in glacial till, and are on side slopes above Terril soils.

Typical pedon of Terril loam, 2 to 5 percent slopes in a cultivated field, 2,400 feet north and 155 feet west of the southeast corner of sec. 17, T. 94 N., R. 39 W.

Ap—0 to 6 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A12—6 to 12 inches; black (10YR 2/1) loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine granular; friable; slightly acid; gradual wavy boundary.

A13—12 to 20 inches; very dark brown (10YR 2/2) loam; dark grayish brown (10YR 4/2) dry; faces of peds black (10YR 2/1); weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; slightly acid; gradual wavy boundary.

A3—20 to 33 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) heavy loam; dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) dry; faces of peds black (10YR 2/1) and very dark gray (10YR 3/1); very dark brown (10YR 2/2) kneaded; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; slightly acid; gradual wavy boundary.

B21—33 to 39 inches; very dark grayish brown (10YR 3/2) clay loam; grayish brown (10YR 5/2) dry; faces of peds very dark brown (10YR 2/2); weak fine prismatic structure parting to weak fine subangular blocky; friable; slightly acid; gradual wavy boundary.

B22—39 to 46 inches; dark brown (10YR 3/3) and brown (10YR 4/3) clay loam; faces of peds very dark grayish brown (10YR 3/2); dark brown (10YR 3/3) kneaded; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; friable; slightly acid; clear wavy boundary.

B3—46 to 51 inches; brown (10YR 4/3) and yellowish brown (10YR 5/4) clay loam; weak medium prismatic structure; friable; few fine yellowish red (5YR 5/8) segregations (oxides); neutral; clear wavy boundary.

C—51 to 60 inches; olive brown (2.5Y 4/4) loam; weak medium prismatic structure; friable; few very fine yellowish red (5YR 5/8) segregations (oxides); strong effervescence; common fine lime filaments and soft masses; moderately alkaline.

The thickness of the solum and depth to carbonates are typically 40 to 60 inches but range from 30 to 60 inches or more. The mollic epipedon is 24 to more than 40 inches thick.

The A horizon has color value of 2 or 3 and chroma of 1 or 2.

The B2 horizon has value of 3 or 4 and chroma of 2 through 4. It is loam or clay loam and slightly acid or neutral except in the lower part where it is moderately alkaline in some pedons.

The C horizon to a depth of 60 inches is clay loam glacial till in some pedons and loam or clay loam alluvium in other pedons. It has value of 4 through 6 and chroma of 3 or 4. Effervescence is slight to strong.

formation of the soils

This section describes the major factors of soil formation, recounts how those factors have affected the soils in O'Brien County, and explains the processes of soil horizon differentiation.

factors of soil formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated as a result of geologic events. The characteristics of a specific soil are determined by (1) the physical properties and the chemical and mineralogical composition of the parent materials; (2) the climate under which the parent material accumulated and existed since accumulation; (3) the plants and animals that have lived on and in the soil and parent material; (4) the relief or lay of the land; and (5) the length of time the soil-forming processes have acted on the soil material.

Climate and plant and animal life act on unconsolidated organic and mineral parent material and slowly change it into a natural soil body that has genetically related horizons. Relief influences the effects of climate and plant and animal life. The parent material affects the kind of soil profile that forms and the rate at which it forms. In extreme cases it determines profile formation almost entirely. Finally, time is required for parent material to change into a soil. The amount of time required is determined by the rate of the soil forming processes. Usually, a long time is required for distinct horizons to form.

The factors of soil formation are interrelated. The effect of one factor cannot be stated unless conditions are specified or known for the other four factors. Even so, the processes of soil formation are not fully known.

parent material

The soils of O'Brien County formed in loess, alluvium, glacial till, and sediment deposited by wind and water.

Loess, a silty material deposited by wind, is the most extensive parent material in the county. Soils that formed partly or entirely in loess make up about 88 percent of O'Brien County. The loess is about 2 to 8 feet thick. It overlies glacial till.

The loess is thickest in the southwestern part of the county where Galva and Primghar soils predominate. These soils have glacial till at a depth of more than 40 inches. Sac and Ransom soils, which are mainly in the northeastern part of the county, have glacial till at a depth of 24 to 40 inches. In general the loess is thicker on plane and concave, nearly level slopes than in convex, gently sloping, or moderately sloping areas.

The loess generally consists of 18 to 25 percent clay-sized particles and less than 10 percent sand-sized particles. Generally there is no gravel nor are there cobbles except near the boundary between the loess and the underlying glacial drift. Concretions and segregations of lime generally are at a depth of 2 to 4 feet.

The loess and the soils that formed in loess in O'Brien County and adjoining counties have been a subject for many studies. Ruhe investigated the chronologic and stratigraphic relationship of the loess and the underlying glacial drift (*17*). Handy reported on the relationship between the clay content of loess and the probability of loess collapse upon saturation (*9*). The physical and chemical data for loess soils in northwestern Iowa, included Galva, Marcus, and Primghar soils, have been published (*7, 30*). Bicki has investigated percolation rates, moisture retention, and other properties of Galva, Galva stratified substratum, Marcus, Primghar, Sac, and Sac Variant soils (*4*). Kovar and Riecken investigated the nonexchangeable potassium and magnesium status of the clay in Ransom and Sac soils (*13*). Von Jolley reported the results of applying nitrogen to loess soils at the Northwest Iowa Experimental Farm, where cropland management responses of Galva, Marcus, Primghar, and Sac soils are investigated and reported annually (*12*).

The soils that formed in loess have a deep root zone if a high water table is not present. The available water capacity is high to very high. In areas where the slope is suitable and the natural or artificial drainage is adequate, these soils are excellent for cultivation.

Alluvium is material deposited by water along streams and in upland drainageways. Soils that formed in alluvium make up about 8 percent of the county. About 66 percent of the soils that formed in alluvium are silty clay loam or silt loam, and 34 percent are loam.

The silty clay loam and silt loam were derived from loess that washed from the uplands and from upland soils that formed in loess. The loam was derived from glacial drift that washed from the uplands and from upland soils that formed in glacial drift. In areas where silty and loamy alluvium are on the larger stream bottom lands, generally the silty alluvium is in slack water areas away from the stream channel or on the part of the bottom land that received alluvium from an upland area

of loess. Some alluvium is transported a short distance and is called local alluvium. Most of the local alluvium is below glacial deposits on steep side slopes.

Seven soils in the county formed in alluvium. Calco and Colo soils, the most extensive, formed in silty clay loam alluvium. Most of the other soils formed in loam alluvium.

Most of the soils that formed in alluvium have a deep root zone if there is no high water table. They also have a high or very high available water capacity. Flooding is a hazard on most of these soils, but in most years flooding occurs late in winter or early in spring. In areas where drainage is adequate and the hazard of flooding during the growing season is not severe, alluvial soils are excellent for cultivation.

Glacial drift is material deposited by glaciers. The two main kinds of glacial drift in O'Brien County are glacial till and glacial outwash. Glacial drift covers all of O'Brien County but is not an extensive parent material because it is overlain by loess or alluvium in most places. The glacial drift in the county is more than 150 feet thick, but in places it is more than 400 feet thick.

Three episodes of glaciation occurred in what is now O'Brien County. The first two, the Nebraskan and the Kansan, left drift deposits over the entire county. The third glacier, the Tazewell substage of the Wisconsinan Glaciation, deposited drift in all the county except the southwestern part. The Tazewell Glaciation extended from Sheldon southeastward to the county boundary south of Paullina (*17*). Two notable features of the Tazewell Glaciation are the gravelly glacial outwash on uplands near Sheldon, Sanborn, and Sutherland and the silty gleyed deposits on upland areas between Sheldon and Primghar. Radiocarbon tests indicate that the Tazewell glacier deposited material in O'Brien County about 22,000 to 14,000 years ago (*17*).

The glacial till in O'Brien County typically is loam or light clay loam. In areas where geologic erosion has removed a large amount of the finer sized particles, there are concentrations of gravel, cobbles, and stones on the surface of the till. These coarse materials are also moved toward the surface by cycles of freezing and thawing when the till is sufficiently moist. The glacial outwash in the county typically is stratified sand or loamy sand and has a variable content of gravel. On low stream benches, the alluvium in the upper 1 1/2 to 3 1/2 feet is loam, clay loam, or silty clay loam. On uplands and high stream benches, the glacial outwash is overlain by 3 to 5 feet of silt loam loess.

In O'Brien County, only the Storden soils formed entirely in glacial till. The Everly soils formed in about 1 1/2 to 3 feet of loamy sediment over glacial till, and the Ocheyedan soils formed in more than 4 feet of loamy sediment over glacial till. Glacial outwash is the parent material of the Estherville, Cylinder, and Biscay soils on stream benches and the Salida soils on stream benches and uplands.

The soils that formed partly or entirely in glacial till have a deep root zone and a high available water capacity. The soils that formed in glacial outwash have a shallow root zone and a moderate to very low available water capacity, depending on the depth to stratified gravelly sand and loamy sand.

Eolian sands are a very minor parent material in the county. Bolan loam is the only soil that formed in loamy and sandy eolian material in the county. Small areas of loamy sand and coarser textured soils are shown on the soil map by a special symbol. The sandy eolian materials are on the south and east sides of the Little Sioux River, Mill Creek, and other major streams. These materials are associated and in places are intermingled with the loess. They are thought to have been deposited during the Tazewell Glaciation. The source area for these sandy deposits was probably the flood plain of the nearby stream.

The surficial bedrock under the loess and glacial drift in O'Brien County is undifferentiated rock of Cretaceous age, according to the Iowa Geological Survey. The logs of deep wells indicate that the upper layers of the bedrock are sandstone and shale. The bedrock has not influenced the development of soils in the county because it is so deeply buried. Water for some towns and farms in the county is pumped from the bedrock.

climate

Climate is a major influence on soil development. Soils develop more rapidly in a warm climate than in a cold climate, and more rapidly in a wet climate than in a dry climate. Except for climatic differences due to topography, the soils in O'Brien County developed in about the same climate. The climate has not, however, been the same during the entire period of soil development.

Development of the present upland soils in O'Brien County began about 14,000 years ago after glaciation in Iowa ended and the climate began a warming trend (*18*). The climate in Iowa since that time has varied considerably (*32*). From about 14,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers.

From 10,500 to about 8,000 years ago, the climate became warmer, and the vegetation changed from conifers to a mixed forest dominated by hardwoods. About 8,000 years ago the climate became progressively warmer and drier until about 3,000 years ago. As a result, herbaceous prairie vegetation replaced the forest vegetation.

Since about 3,000 years ago, to the present, the climate has become more humid and the vegetation dominated by prairie plants has continued except for small areas of trees on the more sloping soils, particularly near the Little Sioux River in the southeastern part of the county.

The present climate in O'Brien County is midcontinental subhumid. There is very little difference in climate from one side of the county to the other. There

is about 1 1/2 inch increase in annual precipitation from the northwest corner of the county to the southeast corner and about a 1 degree increase in mean annual temperature from the northern part of the county to the southern part (*21*).

The effect of climate on soils is modified by relief. Other factors being equal, the more sloping soils, for example, Salida soils, develop under a drier microclimate than nearly level or gently sloping soils, for example, Galva soils.

On the steep Salida soils, however, the microclimate on the north-facing slopes is cooler and moister than on the south-facing slopes. Because of this difference in microclimate, trees are part of the natural vegetation on the north sloping Salida soils but not on the south sloping Salida soils. On poorly drained soils, for example, Afton, Colo, and Marcus soils, the microclimate is cooler and wetter than on the adjoining better drained soils.

Although much of the effect of climate on soil development in O'Brien County is through the influence of climate on vegetation, climate has directly influenced soil development. The amount of precipitation determines the depth to which calcium carbonates, soluble salts, and clay are moved. Precipitation also affects the depth to the water table in poorly drained and somewhat poorly drained soils. In places where the water table is high during most of the growing season, the soil does not develop to so great a depth as it does in places where the water table is not high.

Temperature and moisture conditions affect the rate of weathering of parent material and of soil development. The amount and distribution of rainfall affect the amount of leaching and erosion. Rainfall also affects the kinds of plants on the soil and animals in and on the soil. The direct and indirect influence of climate on soil development is responsible for regional differences among the soils.

plant and animal life

Living organisms are important in soil development. The activities of burrowing animals, for example, worms, crayfish, and micro-organisms, are reflected in soil properties. Vegetation, however, generally causes the most marked differences in soils. Grass, for example, has a dense system of roots in the surface layer. Grass roots die and are replaced relatively often. The dead roots add organic matter to the soil. Soils that formed under grass typically have a thicker, darker colored surface layer than soils that formed under trees; also, they are less acid and generally have a thinner, less developed subsoil than soils that formed under trees.

The soils in O'Brien County formed mainly under prairie grasses. Herbaceous prairie vegetation probably replaced forest vegetation about 8,000 years ago. Trees grew in a relatively small area of O'Brien County in the early 1800's, before settlement (*6*).

Trees have influenced soil development on some steep and very steep soils on north- and east-facing hillsides near the Little Sioux River. Those soils are not extensive in the county.

The large burrowing animals, such as badgers, fox, and pocket gophers, have the most obvious influence on soil development. They drastically affect soil development in small areas. Small animals, such as earthworms and in places ants, have a widespread influence on soil development. Earthworms move up and down in soils as the moisture status of the soil changes. In most soil profiles examined in the county, earthworms had moved material from one soil horizon to another.

Man has changed the natural development of soils most obviously by causing accelerated erosion. For example, most of the moderately sloping Sac soils in the county that have been cultivated for 10 years or more have topsoil that is about 7 inches thick. Where they have not been cultivated or cultivated for only a few years, these soils have topsoil that is about 12 inches thick. Man has also caused changes in microbial activity, organic matter content, and structure of the surface layer.

relief

In O'Brien County, the relief, or topography, ranges from level to very steep. Relief is an important factor in soil formation because it affects drainage, runoff, height of the water table, and erosion. Soils that formed in the same kind of parent material have different properties mainly because of differences in relief.

In O'Brien County, the influence of relief is evident in the soils that formed in loess. These soils differ in color, thickness of the solum, and degree of development of horizons. Galva soils are in convex areas. They are level to moderately sloping and are well drained. Excess water runs off these soils; runoff or subsurface seepage do not collect on the surface. Primghar soils are in plane and concave areas. They are level to gently sloping and are somewhat poorly drained. Marcus soils are in concave areas. They are level and are poorly drained. Primghar and Marcus soils generally receive runoff from adjacent soils, but runoff on these soils is minimal because they are not sloping enough. Primghar and Marcus soils have a seasonal water table within 1 to 3 feet of the surface because of their topographic position and because the glacial till under the loess slows the downward percolation of water. Galva soils do not have a water table within 5 feet of the surface in most places. If the water table rises above the glacial till, it is there for only a short time. Erosion is not a hazard on level Primghar and Marcus soils, but most areas of Galva soils are subject to erosion.

According to the model developed by Runge (*19*), soil development is progressively slower in the Marcus, Primghar, and Galva soils, in that order. Marcus soils have the most water available for plant growth and for the production of organic matter. They are moist enough for clay to form over the longest intervals each year.

Most of the data about these soils indicates that Marcus soils have the greatest amount of organic matter and clay in the upper horizons and that Galva soils have the least.

The degree of horizon development is not so great in Galva soils that are in convex areas as it is in Galva stratified substratum soils that are in concave and plane areas that receive runoff. Laboratory data indicate that the level of available phosphorus in the subsoil is higher in the Galva stratified substratum soils than in the other Galva soils. A similar difference in phosphorus levels attributable to landscape was found by Smeck and Runge in Illinois (*19, 24*).

Relief also influences the color of the B horizon through its effect on surface and subsurface drainage. Galva soils, which are well drained, have a subsoil that is brown because iron compounds are oxidized and distributed throughout the soil material. Marcus soils, which are poorly drained, have a subsoil that is grayish or olive because iron compounds have been deoxidized or reduced.

Relief also influences the distribution of soils through its effect on the thickness of the loess, according to Prill, Shrader, and Nicholson (*16*). Generally, the loess is less thick on convex ridgetops and side slopes than it is on plane to concave positions on the landscape. Sac and Ransom soils are associated with Galva and Primghar soils in some parts of the county. The Sac and Ransom soils generally are on convex ridgetops and side slopes, and the Galva and Primghar soils generally are on plane to concave side slopes and in drainageways.

time

The passage of time enables relief, climate, and plant and animal life to bring about changes in soil material. It takes a few hundred years for topsoil to form, and it takes 8 to 10 times longer for the subsoil to become well developed (*22*). Similar soils form from different kinds of parent material if the other factors of soil development are active for long periods. Soil devlopment, however, is generally interrupted by geological events that expose new parent material.

In O'Brien County the bedrock has been covered by glacial drift from the Nebraskan and Kansan glaciers and more recently by Wisconsinan loess and glacial drift. Except for the soils on modern surfaces, the soils that formed in each of these materials eroded away or were buried by a more recent material.

Radiocarbon dating has been used to determine the age of wood, bones, and other organic carbon materials in Wisconsinan loess and glacial drift. Indications are that the loess was deposited about 30,000 to 14,000 years ago and that the drift was deposited about 22,000 years ago (*17*). In O'Brien County the drift deposits probably ended early in the Wisconsinan period because the drift is mantled by loess. On the basis of these dates, the surface of a stable loess-mantled divide in Iowa is about 14,000 years old. In O'Brien County the soils in these stable areas are Marcus, Primghar, and Galva soils on uplands.

There is evidence in central and northwestern Iowa that considerable erosion occurred 8,000 to 3,000 years ago (*32, 8*). The erosion removed material from sloping areas and deposited sediment in lower lying areas. The surface of these areas, therefore, is thought to be less than 14,000 years old and may be no more than 3,000 years old.

The stream benches in O'Brien County that do not have a loess mantle are thought to be late Wisconsinan in age. Estherville and Cylinder soils are on such terraces. Hallberg, Hoyer, and Miller (*8*) found that the alluvium above the sand and gravel fill along the Little Sioux River, in Cherokee County, is about 10,000 years old.

The youngest surfaces in the county are the steep to very steep side slopes occupied by Storden and Salida soils and the nearly level bottom lands occupied by Colo, Calco, and similar soils. Geologic erosion removes material about as fast as soil development progresses on steep to very steep side slopes. The alluvial sediment from uplands accumulates on bottom lands. Soils that formed in postsettlement alluvium were identified in O'Brien County but were not extensive enough to map.

processes of soil horizon differentiation

The processes of soil horizon differentiation have been defined as *additions, removals, transfers,* and *transformations* (*22*). The rate at which each of these processes occurs determines what kind of soil develops and how rapidly the soil develops. For example, in most soils there are additions of organic matter, removal of soluble salts and carbonates, transfer of clay from the surface downward, and transformation of primary minerals into secondary minerals that can be used by plants.

In general these processes promote horizon differentiation, but in some soils one or more processes retard or reduce soil formation. For example, in a soil that is rapidly eroding, organic matter is being removed faster than it is being added, and the horizon to which clay is being transferred comes closer to the surface as erosion removes the surface layer.

An increase in the content of organic matter is early evidence that horizon differentiation is progressing in soils. For example, the surface layer of Salida soils is darker than the underlying layers because it contains organic matter.

Normal or accelerated erosion has not removed all the soluble salts and calcium carbonate from the surface layer of Salida soils. In other soils on uplands, however, percolating water has removed soluble salts and calcium from the upper horizons and moved them downward. The depth to which the calcium carbonate precipitates indicates the usual depth to which water percolates in

the moist part of the year. The subsoil develops as carbonates are moved downward. A subsoil has developed in Galva and Sac soils in the county.

Transfer of minerals is also important in the differentiation of horizons in O'Brien County soils. Most apparent is the transfer of clay from the surface layer to the developing B horizon. The depth to which clay is moved is related to the rate of water percolation during the growing season (*19*). A transfer becomes a removal when the substance is lost from the soil. In O'Brien County, a significant transfer takes place during the cropping season. Nitrate nitrogen is transferred downward by the percolating water and may even be removed from the soil. Transfers also occur from lower horizons upward, for example, when plant roots take up nitrogen and other elements. There is evidence that elements such as zinc, which are relatively insoluble in water, are transferred from the lower horizons to the surface by plants. The elements, along with clay, are then transferred from the surface to the B horizon as horizon differentiation progresses (*5*).

Transformations occur in all the soil horizons, but the rate of transformation is greatest in the surface layer. During the growing season, organic matter is transformed into mineral elements and primary minerals into secondary mineral elements. Most transformations have the effect of making elements more available to plants. For example, near a pH of 7, the primary mineral apatite is weathered to secondary phosphorus compounds (*10, 20*). Thus, soils that have a pH of more than 7, such as Calco soils, are lower in available phosphorus than soils that have a pH near 7, such as Afton or Colo soils.

Some elements must be transformed before they can be translocated by water in the soil. Oxidized iron, for example, is not soluble in the soil water in well drained soils, such as Galva and Sac soils. In poorly drained soils, such as Marcus and Afton soils, the iron is transformed to its reduced form and moves with the soil water, forming gray or olive gray soil matrix colors and mottles.

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glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	More than 12

Bottom land. The normal flood plain of a stream, subject to flooding.

Chiseling. Tillage with an implement having one or more soil-penetrating points that loosen the subsoil and bring clods to the surface. A form of emergency tillage to control soil blowing.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15.2 to 38.1 centimeters (6 to 15 inches) long.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage system that does not invert the soil and that leaves all or part of the crop residue on the surface throughout the year.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some

are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced

by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.20 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff water.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by *relief* over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an erosional surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsurface layer. Any surface soil horizon (A1, A2, or A3) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A horizon, including all subdivisions of this horizon (A1, A2, and A3).

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1951-74 at Sanborn, Iowa]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days[1]	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	23.3	4.0	13.5	48	-27	0	.49	.17	.74	2	6.6
February---	29.5	10.2	19.9	52	-20	0	1.08	.28	1.71	3	10.2
March------	39.9	20.4	30.2	72	-10	28	1.64	.81	2.32	4	11.7
April------	58.6	34.4	46.6	86	15	56	2.26	1.23	3.10	5	1.6
May--------	71.4	46.3	58.9	91	25	289	3.53	1.89	4.87	7	.0
June-------	80.6	56.6	68.6	96	40	558	4.18	2.49	5.68	7	.0
July-------	84.5	60.7	72.6	97	44	701	3.24	1.48	4.67	6	.0
August-----	82.4	58.7	70.6	96	44	639	3.96	2.01	5.55	6	.0
September--	72.7	48.8	60.8	92	30	324	3.15	1.07	4.81	5	.0
October----	62.4	38.9	50.7	86	16	143	1.83	.73	2.73	4	.5
November---	43.6	24.1	33.9	68	-2	6	.98	.31	1.50	3	3.5
December---	29.2	11.4	20.3	55	-20	0	.81	.40	1.14	2	8.6
Year-----	56.5	34.5	45.6	99	-27	2,744	27.15	21.82	32.22	54	42.7

[1]A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-74 at Sanborn, Iowa]

Probability	Temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	May 1	May 12	May 21
2 years in 10 later than--	April 25	May 7	May 16
5 years in 10 later than--	April 15	April 28	May 7
First freezing temperature in fall:			
1 year in 10 earlier than--	October 7	September 28	September 18
2 years in 10 earlier than--	October 12	October 3	September 24
5 years in 10 earlier than--	October 21	October 11	October 4

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-74 at Sanborn, Iowa]

Probability	Daily minimum temperature		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	172	147	129
8 years in 10	178	153	136
5 years in 10	189	165	149
2 years in 10	200	177	162
1 year in 10	206	183	168

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
26	Kennebec silty clay loam, 0 to 2 percent slopes	335	0.1
27B	Terril loam, 2 to 5 percent slopes	690	0.2
27C	Terril loam, 5 to 14 percent slopes	860	0.2
31	Afton silty clay loam, 0 to 2 percent slopes	7,790	2.1
32	Spicer silty clay loam, 0 to 2 percent slopes	765	0.2
72B	Estherville loam, 1 to 4 percent slopes	485	0.1
72D	Estherville loam, 5 to 14 percent slopes	445	0.1
73E	Salida sandy loam, 9 to 18 percent slopes	200	0.1
73F	Salida sandy loam, 18 to 40 percent slopes	230	0.1
77B	Sac silty clay loam, 2 to 5 percent slopes	33,195	9.0
77C2	Sac silty clay loam, 5 to 9 percent slopes, moderately eroded	3,340	0.9
89B	Sac Variant silty clay loam, 2 to 5 percent slopes	605	0.2
89C2	Sac Variant silty clay loam, 5 to 9 percent slopes, moderately eroded	205	0.1
91	Primghar silty clay loam, 0 to 2 percent slopes	64,970	17.6
91B	Primghar silty clay loam, 2 to 4 percent slopes	35,400	9.6
92	Marcus silty clay loam, 0 to 2 percent slopes	48,540	13.2
133	Colo silty clay loam, 0 to 2 percent slopes	11,870	3.2
202	Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	205	0.1
203	Cylinder silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	370	0.1
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	650	0.2
282	Ransom silty clay loam, 1 to 3 percent slopes	3,245	0.9
310	Galva silty clay loam, 0 to 2 percent slopes	17,860	4.8
310B	Galva silty clay loam, 2 to 5 percent slopes	104,065	28.2
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	615	0.2
311	Galva silty clay loam, stratified substratum, 0 to 2 percent slopes	5,190	1.4
311B	Galva silty clay loam, stratified substratum, 2 to 5 percent slopes	1,145	0.3
433D	Storden loam, 9 to 14 percent slopes	720	0.2
433E	Storden loam, 14 to 18 percent slopes	400	0.1
433F	Storden loam, 18 to 25 percent slopes	1,125	0.3
433G	Storden loam, 25 to 40 percent slopes	3,175	0.8
474B	Bolan loam, 2 to 5 percent slopes	210	0.1
474C	Bolan loam, 5 to 14 percent slopes	260	0.1
485	Spillville loam, 0 to 2 percent slopes	1,060	0.3
505	Sperry silty clay loam, 0 to 1 percent slopes	205	0.1
577C2	Everly clay loam, 5 to 9 percent slopes, moderately eroded	260	0.1
577D	Everly clay loam, 9 to 14 percent slopes	340	0.1
639G	Storden-Salida complex, 25 to 40 percent slopes	240	0.1
708B	Fairhaven silt loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	765	0.2
708C2	Fairhaven silt loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	405	0.1
709	Fairhaven silt loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	270	0.1
709B	Fairhaven silt loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	965	0.2
733	Calco silty clay loam, 0 to 2 percent slopes	6,220	1.7
785	Spillco loam, 0 to 2 percent slopes	5,505	1.5
878B	Ocheyedan loam, 2 to 5 percent slopes	400	0.1
1658C	Terril-Colo complex, channeled, 2 to 10 percent slopes	380	0.1
1785	Spillco loam, channeled, 0 to 2 percent slopes	625	0.2
5010	Pits, gravel	365	0.1
5040	Orthents, loamy	510	0.1
	Water	260	0.1
	Total	367,935	100.0

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	Bu	Bu	Ton	AUM*	AUM*
26------------------------ Kennebec	103	39	88	3.9	6.5	4.2
27B----------------------- Terril	94	36	81	3.6	6.0	4.2
27C----------------------- Terril	85	32	72	3.4	5.5	3.9
31------------------------ Afton	93	35	79	3.5	5.8	4.1
32------------------------ Spicer	92	35	80	3.5	5.8	4.1
72B----------------------- Estherville	50	19	50	2.0	3.3	2.3
72D----------------------- Estherville	30	10	30	1.5	2.5	1.8
73E----------------------- Salida	---	---	---	1.0	1.7	1.2
73F----------------------- Salida	---	---	---	---	1.3	0.8
77B----------------------- Sac	89	34	76	3.4	5.7	3.9
77C2---------------------- Sac	81	31	69	3.1	5.2	3.6
89B----------------------- Sac Variant	89	34	76	3.4	5.7	3.9
89C2---------------------- Sac Variant	81	31	69	3.1	5.2	3.6
91------------------------ Primghar	103	39	88	3.9	6.5	4.2
91B----------------------- Primghar	101	38	86	3.8	6.3	4.2
92------------------------ Marcus	99	38	84	3.8	6.0	4.2
133----------------------- Colo	91	35	78	3.5	5.8	4.1
202----------------------- Cylinder	80	31	70	3.1	5.2	3.6
203----------------------- Cylinder	95	36	82	3.7	6.2	4.2
259----------------------- Biscay	94	36	80	3.6	6.0	4.2
282----------------------- Ransom	100	38	85	3.9	6.5	4.2

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	Bu	Bu	Ton	AUM*	AUM*
310------------------- Galva	97	37	82	3.7	6.2	4.2
310B------------------ Galva	95	36	81	3.6	6.0	4.2
310C2----------------- Galva	87	33	74	3.3	5.5	3.8
311------------------- Galva	97	37	82	3.7	6.2	4.2
311B------------------ Galva	95	36	81	3.6	6.0	4.2
433D------------------ Storden	68	26	58	2.6	4.3	3.0
433E------------------ Storden	50	---	43	2.0	3.3	2.3
433F------------------ Storden	---	---	---	1.8	3.0	2.0
433G------------------ Storden	---	---	---	---	---	1.5
474B------------------ Bolan	72	27	72	2.8	4.5	3.2
474C------------------ Bolan	51	20	51	2.0	3.3	2.3
485------------------- Spillville	88	33	75	3.6	5.9	4.1
505------------------- Sperry	82	31	53	3.2	5.3	3.7
577C2----------------- Everly	77	29	65	3.0	5.0	3.5
577D------------------ Everly	70	27	60	2.7	4.5	3.2
639G------------------ Storden-Salida	---	---	---	---	2.0	1.4
708B------------------ Fairhaven	64	24	64	2.5	4.2	2.9
708C2----------------- Fairhaven	54	21	54	2.1	3.5	2.5
709------------------- Fairhaven	86	33	73	3.3	5.5	3.9
709B------------------ Fairhaven	84	32	71	3.2	5.3	3.7
733------------------- Calco	88	33	75	3.5	5.8	4.1
785------------------- Spillco	87	32	72	3.5	5.5	3.5
878B------------------ Ocheyedan	80	29	68	3.0	5.0	3.5

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	Bu	Bu	Ton	AUM*	AUM*
1658C----------------------- Terril-Colo	---	---	---	---	5.6	3.9
1785----------------------- Spillco	---	---	---	---	3.3	2.3
5010. Pits						
5040. Orthents						

* Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

TABLE 6.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	91,935	---	---	---
II	260,975	177,040	83,360	575
III	7,885	7,195	205	485
IV	845	400	---	445
V	190	---	190	---
VI	1,325	1,125	---	200
VII	3,645	3,319	---	326
VIII	---	---	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
26----------------- Kennebec	Gray dogwood, silky dogwood, common ninebark.	Tatarian honeysuckle, redosier dogwood, Siberian peashrub.	Amur maple, eastern redcedar, blue spruce, white spruce.	Common hackberry, Norway spruce, eastern white pine.	Silver maple, eastern cottonwood.
27B, 27C---------- Terril	Gray dogwood, silky dogwood.	Tatarian honey- suckle, redosier dogwood, lilac.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
31---------------- Afton	Silky dogwood, common ninebark.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub, Amur honeysuckle, lilac.	Amur maple, blue spruce, white spruce.	Green ash, Scotch pine, eastern white pine.	Eastern cottonwood, silver maple.
32---------------- Spicer	Common ninebark---	Tatarian honey- suckle, redosier dogwood.	Russian-olive, eastern redcedar, northern white- cedar.	Green ash, bur oak, honeylocust.	Eastern cottonwood.
72B, 72D---------- Estherville	American plum, common ninebark, lilac.	Eastern redcedar, Russian-olive, Tatarian honey- suckle, Siberian peashrub.	Ponderosa pine, Austrian pine, common hackberry.	Honeylocust-------	---
73E, 73F---------- Salida	Siberian peashrub, coralberry, lilac.	Eastern redcedar, Tatarian honey- suckle.	Ponderosa pine, green ash, honey- locust, red pine.	---	---
77B, 77C2--------- Sac	Coralberry, gray dogwood.	Tatarian honey- suckle, Siberian peashrub, lilac.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
89B, 89C2--------- Sac Variant	Silky dogwood, gray dogwood.	Siberian peashrub, Tatarian honey- suckle.	Amur maple, eastern redcedar.	Norway spruce, common hackberry, red pine, green ash.	Silver maple, eastern cottonwood.
91, 91B----------- Primghar	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
92---------------- Marcus	Coralberry, common ninebark.	Silky dogwood, Tatarian honeysuckle, Siberian peashrub, Zabel honeysuckle.	Amur maple, northern white- cedar, Norway spruce, white spruce.	Green ash, common hackberry.	Eastern cottonwood, silver maple.
133--------------- Colo	Coralberry, common ninebark.	Silky dogwood, Tatarian honey- suckle, Zabel honeysuckle.	Norway spruce, Amur maple, northern white- cedar.	Green ash, common hackberry.	Silver maple, eastern cottonwood.
202--------------- Cylinder	Silky dogwood, gray dogwood, coralberry.	Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, blue spruce, white spruce.	Red pine, Norway spruce, common hackberry, green ash, eastern white pine.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
203----------------Cylinder	Silky dogwood, gray dogwood, coralberry.	Siberian peashrub, Tatarian honeysuckle.	Eastern redcedar, blue spruce, white spruce.	Red pine, Norway spruce, common hackberry, green ash, eastern white pine.	Eastern cottonwood.
259----------------Biscay	Coralberry, common ninebark.	Northern white-cedar, redosier dogwood, Tatarian honeysuckle, silky dogwood.	Eastern redcedar, Russian-olive.	Green ash, honeylocust, bur oak.	Eastern cottonwood.
282----------------Ransom	Silky dogwood, gray dogwood, coralberry.	Tatarian honeysuckle, lilac, American plum.	Eastern redcedar, white spruce, Sargent crabapple.	Common hackberry, Russian-olive, green ash, Norway spruce.	Eastern cottonwood.
310, 310B, 310C2, 311, 311B---------Galva	Silky dogwood, gray dogwood, coralberry.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Amur maple, blue spruce.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
433D---------------Storden	Coralberry, common ninebark.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub, northern white-cedar.	Eastern redcedar	Green ash, Russian-olive, honeylocust, bur oak.	Siberian elm.
433E, 433F, 433G--Storden	Coralberry, common ninebark.	Siberian peashrub, redosier dogwood, Tatarian honeysuckle.	Eastern redcedar	Green ash----------	---
474B, 474C---------Bolan	Redosier dogwood, gray dogwood.	Tatarian honeysuckle, Siberian peashrub, lilac.	Eastern redcedar, Russian-olive.	Red pine, Norway spruce, common hackberry, green ash.	Silver maple.
485----------------Spillville	Silky dogwood, gray dogwood.	Tatarian honeysuckle, lilac, Siberian peashrub.	Amur maple, eastern redcedar.	Common hackberry, white pine, Norway spruce, green ash.	Eastern cottonwood, silver maple.
505----------------Sperry	Silky dogwood, common ninebark, coralberry.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub, Zabel honeysuckle.	Amur maple, northern white-cedar, white spruce.	Green ash, common hackberry.	Eastern cottonwood, silver maple.
577C2, 577D--------Everly	Silky dogwood, gray dogwood, coralberry, lilac.	Siberian peashrub, redosier dogwood, Tatarian honeysuckle.	Eastern redcedar	Norway spruce, common hackberry, green ash, Russian-olive.	---
639G:					
Storden------------	Coralberry, common ninebark.	Siberian peashrub, redosier dogwood, Tatarian honeysuckle.	Eastern redcedar	Green ash, Russian-olive.	---
Salida------------	Siberian peashrub, coralberry.	Tatarian honeysuckle, eastern redcedar.	Ponderosa pine, green ash.	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
708B, 708C2, 709, 709B. Fairhaven	Redosier dogwood, gray dogwood.	American plum, Tatarian honeysuckle, lilac, Siberian crabapple, Amur maple.	Eastern redcedar, eastern white pine, red pine, Russian-olive, northern white-cedar.	Green ash, honey-locust, common hackberry.	Silver maple.
733. Calco	Common ninebark, Siberian peashrub.	Redosier dogwood, Tatarian honeysuckle, American plum.	Russian-olive, eastern redcedar.	Green ash, bur oak, honeylocust.	Eastern cottonwood.
785. Spillco	Silky dogwood, gray dogwood, coralberry.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
878B. Ocheyedan	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
1658C:					
Terril	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry, green ash.	Silver maple, eastern cottonwood.
Colo	Coralberry, common ninebark.	Redosier dogwood, Tatarian honey-suckle, Zabel honeysuckle.	Norway spruce, Amur maple, northern white-cedar.	Green ash, common hackberry.	Silver maple, eastern cottonwood.
1785. Spillco	Silky dogwood, gray dogwood.	Redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Amur maple.	Red pine, Norway spruce, common hackberry, green ash.	Eastern cottonwood, silver maple.
5010. Pits					
5040. Orthents					

TABLE 8.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
26 Kennebec	Severe: floods.	Slight	Moderate: floods.	Slight	Moderate: floods.
27B Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
27C Terril	Slight	Slight	Severe: slope.	Slight	Slight.
31 Afton	Severe: wetness, floods.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: wetness, floods.
32 Spicer	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
72B Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
72D Estherville	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
73E Salida	Moderate: slope, small stones.	Moderate: slope, small stones.	Severe: slope, small stones.	Moderate: small stones.	Severe: small stones.
73F Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Severe: slope.	Severe: slope, small stones.
77B Sac	Slight	Slight	Moderate: slope.	Slight	Slight.
77C2 Sac	Slight	Slight	Severe: slope.	Slight	Slight.
89B Sac Variant	Slight	Slight	Moderate: slope.	Slight	Slight.
89C2 Sac Variant	Slight	Slight	Severe: slope.	Slight	Slight.
91 Primghar	Slight	Slight	Slight	Slight	Slight.
91B Primghar	Slight	Slight	Moderate: slope.	Slight	Slight.
92 Marcus	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
133 Colo	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: floods, wetness.	Severe: floods, wetness.
202, 203 Cylinder	Slight	Slight	Slight	Slight	Slight.
259 Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
282 Ransom	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
310: Galva	Slight	Slight	Slight	Slight	Slight.
310B: Galva	Slight	Slight	Moderate: slope.	Slight	Slight.
310C2: Galva	Slight	Slight	Severe: slope.	Slight	Slight.
311: Galva	Slight	Slight	Slight	Slight	Slight.
311B: Galva	Slight	Slight	Moderate: slope.	Slight	Slight.
433D: Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
433E, 433F: Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
433G: Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
474B: Bolan	Slight	Slight	Moderate: slope.	Slight	Slight.
474C: Bolan	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
485: Spillville	Severe: floods.	Slight	Moderate: floods.	Slight	Moderate: floods.
505: Sperry	Severe: percs slowly, wetness, floods.	Severe: wetness, percs slowly.	Severe: percs slowly, wetness, floods.	Severe: wetness.	Severe: wetness, floods.
577C2: Everly	Slight	Slight	Severe: slope.	Slight	Slight.
577D: Everly	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
639G:					
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Severe: slope.	Severe: slope, small stones.
708B: Fairhaven	Slight	Slight	Moderate: slope.	Slight	Slight.
708C2: Fairhaven	Slight	Slight	Severe: slope.	Slight	Slight.
709: Fairhaven	Slight	Slight	Slight	Slight	Slight.
709B: Fairhaven	Slight	Slight	Moderate: slope.	Slight	Slight.
733: Calco	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
785------------------- Spillco	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.	Severe: floods.
878B------------------ Ocheyedan	Slight----------	Slight----------	Moderate: slope.	Slight------------	Slight.
1658C:					
Terril----------------	Slight----------	Slight----------	Severe: slope.	Slight------------	Slight.
Colo------------------	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: floods, wetness.	Severe: floods.
1785------------------ Spillco	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.	Severe: floods.
5010. Pits					
5040. Orthents					

TABLE 9.--WILDLIFE HABITAT

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
26----------------- Kennebec	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor
27B---------------- Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor
27C---------------- Terril	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
31----------------- Afton	Good	Good	Good	Fair	Poor	Good	Fair	Good	Fair	Fair
32----------------- Spicer	Good	Good	Good	Fair	Poor	Good	Fair	Good	Fair	Fair
72B, 72D----------- Estherville	Fair	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor
73E---------------- Salida	Very poor	Poor	Poor	Poor	Poor	Very poor	Very poor	Very poor	Poor	Very poor
73F---------------- Salida	Very poor	Very poor	Poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor
77B---------------- Sac	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
77C2--------------- Sac	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
89B---------------- Sac Variant	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
89C2--------------- Sac Variant	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
91, 91B------------ Primghar	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair
92----------------- Marcus	Good	Good	Good	Fair	Poor	Good	Fair	Good	Fair	Fair
133---------------- Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good
202, 203----------- Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair
259---------------- Biscay	Good	Good	Good	Fair	Poor	Good	Fair	Good	Fair	Fair
282---------------- Ransom	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair
310, 310B---------- Galva	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
310C2-------------- Galva	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
311, 311B---------- Galva	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor

TABLE 9.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herba-ceous plants	Hardwood trees	Conif-erous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
433D, 433E Storden	Fair	Good	Good	Fair	Poor	Very poor	Very poor	Fair	Fair	Very poor
433F, 433G Storden	Poor	Fair	Good	Fair	Poor	Very poor	Very poor	Fair	Fair	Very poor
474B Bolan	Fair	Fair	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor
474C Bolan	Fair	Fair	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor
485 Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair
505 Sperry	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good
577C2, 577D Everly	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
639G:										
Storden	Poor	Fair	Good	Fair	Poor	Very poor	Very poor	Fair	Fair	Very poor
Salida	Very poor	Very poor	Poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor
708B Fairhaven	Good	Good	Good	Fair	Fair	Very poor	Very poor	Good	Fair	Very poor
708C2 Fairhaven	Fair	Good	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor
709, 709B Fairhaven	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Fair	Very poor
733 Calco	Good	Fair	Good	Fair	Very poor	Good	Good	Fair	Poor	Fair
785 Spillco	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair
878B Ocheyedan	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor
1658C:										
Terril	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor
Colo	Good	Fair	Good	Fair	Poor	Fair	Very poor	Fair	Fair	Poor
1785 Spillco	Poor	Fair	Fair	Poor	Very poor	Fair	Good	Fair	Poor	Fair
5010. Pits										
5040. Orthents										

TABLE 10.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
26 Kennebec	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action, low strength.	Moderate: floods.
27B Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
27C Terril	Slight	Slight	Slight	Moderate: slope.	Severe: low strength.	Slight.
31 Afton	Severe: wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, low strength, floods.	Severe: wetness, floods.
32 Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action, low strength.	Severe: wetness.
72B Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
72D Estherville	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.
73E Salida	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: small stones.
73F Salida	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, small stones.
77B Sac	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
77C2 Sac	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength, frost action.	Slight.
89B Sac Variant	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
89C2 Sac Variant	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength, frost action.	Slight.
91, 91B Primghar	Moderate: wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength, frost action.	Slight.
92 Marcus	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, low strength, frost action.	Moderate: wetness.
133 Colo	Severe: wetness, floods.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, low strength, shrink-swell.	Severe: floods.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
202, 203: Cylinder	Severe: cutbanks cave.	Moderate: shrink-swell.	Severe: wetness.	Moderate: shrink-swell.	Severe: frost action, low strength.	Slight.
259: Biscay	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action.	Moderate: wetness.
282: Ransom	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.	Slight.
310, 310B: Galva	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
310C2: Galva	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength, frost action.	Slight.
311, 311B: Galva	Severe: cutbanks cave.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
433D: Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action, low strength.	Moderate: slope.
433E, 433F, 433G: Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
474B: Bolan	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.	Slight.
474C: Bolan	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: frost action, slope.	Moderate: slope.
485: Spillville	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Moderate: floods.
505: Sperry	Severe: wetness, floods.	Severe: wetness, shrink-swell, floods.	Severe: shrink-swell, wetness, floods.	Severe: shrink-swell, wetness, floods.	Severe: floods, wetness, low strength.	Severe: wetness, floods.
577C2: Everly	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: low strength.	Slight.
577D: Everly	Moderate: slope.	Moderate: slope, shrink-swell.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
639G:						
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Salida	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, small stones.
708B: Fairhaven	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: low strength, frost action.	Slight.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
708C2: Fairhaven	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Moderate: low strength, frost action.	Slight.
709, 709B: Fairhaven	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: low strength, frost action.	Slight.
733: Calco	Severe: wetness, floods.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength, floods.	Severe: floods.
785: Spillco	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action, low strength.	Severe: floods.
878B: Ocheyedan	Slight	Slight	Slight	Slight	Moderate: low strength, frost action.	Slight.
1658C:						
Terril	Slight	Slight	Slight	Moderate: slope.	Severe: low strength.	Slight.
Colo	Severe: wetness, floods.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, low strength, shrink-swell.	Severe: floods.
1785: Spillco	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action, low strength.	Severe: floods.
5010. Pits						
5040. Orthents						

TABLE 11.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
26 Kennebec	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
27B Terril	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Good.
27C Terril	Slight	Severe: slope.	Moderate: too clayey.	Slight	Good.
31 Afton	Severe: wetness, floods.	Severe: wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
32 Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
72B Estherville	Slight*	Severe: seepage.	Severe: too sandy, seepage.	Severe: seepage.	Poor: too sandy, seepage.
72D Estherville	Moderate*: slope.	Severe: seepage, slope.	Severe: too sandy, seepage.	Severe: seepage.	Poor: too sandy, seepage.
73E Salida	Moderate*: slope.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: too sandy, seepage, small stones.
73F Salida	Severe*: slope.	Severe: seepage, slope.	Severe: seepage, slope, too sandy.	Severe: seepage, slope.	Poor: too sandy, seepage, small stones.
77B Sac	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
77C2 Sac	Slight	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
89B Sac Variant	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
89C2 Sac Variant	Slight	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
91, 91B Primghar	Severe: wetness.	Severe: wetness.	Moderate: wetness, too clayey.	Severe: wetness.	Fair: too clayey, wetness.
92 Marcus	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
133 Colo	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
202, 203----------- Cylinder	Severe*: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
259---------------- Biscay	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: wetness, seepage.	Poor: wetness, too sandy, seepage.
282---------------- Ransom	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness, too clayey.
310---------------- Galva	Slight-----------	Moderate: seepage.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
310B--------------- Galva	Slight-----------	Moderate: slope, seepage.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
310C2-------------- Galva	Slight-----------	Severe: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
311, 311B---------- Galva	Slight-----------	Severe: seepage.	Severe: seepage.	Slight-----------	Fair: too clayey.
433D--------------- Storden	Moderate: slope.	Severe: slope.	Slight-----------	Moderate: slope.	Fair: slope.
433E, 433F--------- Storden	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.	Poor: slope.
433G--------------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
474B--------------- Bolan	Slight*----------	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Good.
474C--------------- Bolan	Moderate*: slope.	Severe: slope, seepage.	Severe: seepage, too sandy.	Severe: seepage.	Fair: slope.
485---------------- Spillville	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Fair: wetness.
505---------------- Sperry	Severe: percs slowly, wetness, floods.	Severe: wetness.	Severe: wetness, floods, too clayey.	Severe: wetness, floods.	Poor: wetness.
577C2-------------- Everly	Slight-----------	Severe: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
577D--------------- Everly	Moderate: slope.	Severe: slope.	Moderate: too clayey.	Moderate: slope.	Fair: too clayey, slope.
639G: Storden-----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
639G:					
Salida	Severe*: slope.	Severe: seepage, slope.	Severe: seepage, slope, too sandy.	Severe: seepage, slope.	Poor: too sandy, seepage, small stones.
708B Fairhaven	Slight*	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
708C2 Fairhaven	Slight*	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
709, 709B Fairhaven	Slight*	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
733 Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
785 Spillco	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Fair: wetness.
878B Ocheyedan	Slight	Severe: seepage.	Slight	Severe: seepage.	Good.
1658C*:					
Terril	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Good.
Colo	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
1785 Spillco	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Poor: wetness.
5010. Pits					
5040. Orthents					

* Pollution of ground water is a possibility.

TABLE 12.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
26 Kennebec	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
27B, 27C Terril	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
31 Afton	Poor: wetness, low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
32 Spicer	Poor: wetness, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
72B, 72D Estherville	Good	Good	Good	Poor: area reclaim.
73E Salida	Good	Good	Good	Poor: small stones, area reclaim.
73F Salida	Poor: slope.	Good	Good	Poor: small stones, slope, area reclaim.
77B, 77C2 Sac	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
89B, 89C2 Sac Variant	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
91, 91B Primghar	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
92 Marcus	Poor: wetness, low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
133 Colo	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
202, 203 Cylinder	Good	Good	Fair: excess fines.	Fair: area reclaim.
259 Biscay	Poor: wetness.	Good	Good	Fair: too clayey.
282 Ransom	Fair: low strength, wetness.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
310, 310B, 310C2 Galva	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
311, 311B Galva	Good	Good	Good	Fair: too clayey.
433D Storden	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: slope, small stones.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
433E, 433F Storden	Fair: slope, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
433G Storden	Poor: slope.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
474B Bolan	Good	Fair: excess fines.	Unsuited: excess fines.	Good.
474C Bolan	Good	Fair: excess fines.	Unsuited: excess fines.	Fair: slope.
485 Spillville	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
505 Sperry	Poor: low strength, shrink-swell, wetness.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: wetness.
577C2 Everly	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
577D Everly	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: slope.
639G:				
Storden	Poor: slope.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: slope.
Salida	Poor: slope.	Good	Good	Poor: small stones, slope, area reclaim.
708B, 708C2, 709, 709B Fairhaven	Good	Good	Unsuited: excess fines.	Fair: area reclaim.
733 Calco	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
785 Spillco	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
878B Ocheyedan	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
1658C:				
Terril	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Colo	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
1785 Spillco	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
5010. Pits				
5040. Orthents				

TABLE 13.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
26 Kennebec	Seepage	Favorable	Floods, frost action.	Floods	Erodes easily	Erodes easily.
27B, 27C Terril	Seepage, slope.	Favorable	Not needed	Slope	Favorable	Favorable.
31 Afton	Favorable	Wetness, hard to pack.	Floods, frost action.	Wetness, floods.	Wetness, erodes easily.	Wetness, erodes easily.
32 Spicer	Seepage	Wetness, piping.	Frost action	Wetness	Not needed	Wetness.
72B Estherville	Seepage	Seepage	Not needed	Droughty	Too sandy	Droughty.
72D Estherville	Seepage, slope.	Seepage	Not needed	Droughty, slope.	Too sandy, slope.	Slope, droughty.
73E, 73F Salida	Seepage, slope.	Seepage	Not needed	Slope, droughty, fast intake.	Slope, too sandy.	Slope, droughty.
77B, 77C2 Sac	Seepage, slope.	Favorable	Not needed	Slope	Erodes easily	Erodes easily.
89B, 89C2 Sac Variant	Seepage, slope.	Favorable	Not needed	Slope	Erodes easily	Erodes easily.
91 Primghar	Favorable	Hard to pack	Not needed	Favorable	Erodes easily	Erodes easily.
91B Primghar	Slope	Hard to pack	Not needed	Slope	Erodes easily	Erodes easily.
92 Marcus	Favorable	Hard to pack, wetness.	Frost action	Wetness	Wetness, erodes easily.	Wetness, erodes easily.
133 Colo	Seepage	Hard to pack, wetness.	Floods, frost action.	Floods, wetness.	Wetness	Wetness.
202, 203 Cylinder	Seepage	Seepage	Frost action, cutbanks cave.	Wetness	Wetness	Favorable.
259 Biscay	Seepage	Seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness	Wetness.
282 Ransom	Favorable	Wetness	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
310 Galva	Seepage	Favorable	Not needed	Favorable	Erodes easily	Erodes easily.
310B, 310C2 Galva	Seepage, slope.	Favorable	Not needed	Slope	Erodes easily	Erodes easily.
311 Galva	Seepage	Favorable	Not needed	Favorable	Erodes easily	Erodes easily.
311B Galva	Seepage, slope.	Favorable	Not needed	Slope	Erodes easily	Erodes easily.
433D Storden	Slope, seepage.	Favorable	Not needed	Slope	Favorable	Slope, erodes easily.
433E, 433F, 433G Storden	Slope, seepage.	Favorable	Not needed	Slope	Slope	Slope, erodes easily.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
474B Bolan	Seepage, slope.	Seepage, piping.	Not needed	Slope	Too sandy	Favorable.
474C Bolan	Seepage, slope.	Seepage, piping.	Not needed	Slope	Slope, too sandy.	Slope.
485 Spillville	Seepage	Favorable	Not needed	Floods	Favorable	Favorable.
505 Sperry	Favorable	Wetness	Percs slowly, frost action, floods.	Percs slowly, wetness, floods.	Wetness, erodes easily, percs slowly.	Wetness, percs slowly, erodes easily.
577C2 Everly	Seepage, slope.	Favorable	Not needed	Slope	Favorable	Favorable.
577D Everly	Seepage, slope.	Favorable	Not needed	Slope	Slope	Slope.
639G:						
Storden	Slope, seepage.	Favorable	Not needed	Slope	Slope	Slope, erodes easily.
Salida	Seepage, slope.	Seepage	Not needed	Slope, droughty, fast intake.	Slope, too sandy.	Slope, droughty.
708B, 708C2 Fairhaven	Seepage, slope.	Seepage	Not needed	Slope	Too sandy, erodes easily.	Erodes easily.
709 Fairhaven	Seepage	Seepage	Not needed	Favorable	Too sandy, erodes easily.	Erodes easily.
709B Fairhaven	Seepage, slope.	Seepage	Not needed	Slope	Too sandy, erodes easily.	Erodes easily.
733 Calco	Seepage	Hard to pack, wetness.	Floods, frost action.	Floods, wetness.	Wetness	Wetness.
785 Spillco	Seepage	Favorable	Not needed	Floods	Favorable	Favorable.
878B Ocheyedan	Seepage	Favorable	Not needed	Favorable	Favorable	Favorable.
1658C:						
Terril	Seepage, slope.	Favorable	Not needed	Slope	Favorable	Favorable.
Colo	Seepage	Hard to pack, wetness.	Floods, frost action.	Floods, wetness.	Wetness	Wetness.
1785 Spillco	Seepage	Favorable	Floods	Floods	Favorable	Favorable.
5010. Pits						
5040. Orthents						

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS

[The symbol > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
26----------------- Kennebec	0-31	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	90-100	25-45	10-20
	31-60	Silt loam, silty clay loam.	CL, CL-ML	A-6, A-4	0	100	100	95-100	90-100	25-40	5-15
27B, 27C----------- Terril	0-33	Loam------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	33-60	Clay loam-------	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
31----------------- Afton	0-26	Silty clay loam	MH, CH	A-7	0	100	100	100	95-100	50-65	20-35
	26-51	Silty clay loam, silt loam.	CL, CH	A-7	0	100	100	100	95-100	40-60	20-35
	51-60	Clay loam, silt loam, silty clay loam.	CL	A-6, A-7	0	100	95-100	80-100	60-90	35-50	20-30
32----------------- Spicer	0-19	Silty clay loam	ML, CL	A-7	0	100	100	95-100	90-100	40-55	15-25
	19-38	Silt loam, silty clay loam.	ML, CL, MH, CH	A-7	0	100	100	95-100	85-100	40-55	15-20
	38-60	Silt loam-------	CL	A-6	0	100	100	95-100	85-100	30-40	10-20
72B, 72D----------- Estherville	0-13	Loam------------	CL-ML, CL	A-4, A-6	0-5	90-100	80-95	50-75	50-60	25-40	4-15
	13-25	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	70-95	40-75	15-45	20-30	2-8
	25-60	Coarse sand, gravelly coarse loamy sand, loamy coarse sand.	SP, SP-SM, SM, GP	A-1	0-10	45-90	40-85	10-40	2-25	---	NP
73E, 73F----------- Salida	0-9	Sandy loam, gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	9-60	Gravelly loamy sand, sand, gravelly loamy coarse sand.	SP, SW, GP, GP-GM	A-1	0-5	50-90	40-60	10-30	2-25	---	NP
77B---------------- Sac	0-12	Silty clay loam	ML, CL, MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
	12-31	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	31-60	Clay loam, loam	CL, ML	A-6	2-5	95-100	90-100	75-90	65-80	30-40	10-20
77C2--------------- Sac	0-7	Silty clay loam	ML, CL, MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
	7-28	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	28-60	Clay loam, loam	CL, ML	A-6	2-5	95-100	90-100	75-90	65-80	30-40	10-20
89B, 89C2---------- Sac Variant	0-11	Silty clay loam	ML, CL, MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
	11-28	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	28-60	Silt loam, silty clay loam.	CL-ML, CL	A-4, A-6	0	95-100	95-100	85-95	75-90	25-40	5-15
91, 91B------------ Primghar	0-17	Silty clay loam	MH, CH	A-7	0	100	100	95-100	90-100	50-60	20-40
	17-35	Silty clay loam	CL, CH	A-7	0	100	100	95-100	90-100	40-55	20-30
	35-44	Silt loam-------	CL	A-6	0	100	100	95-100	90-100	30-40	11-20
	44-60	Clay loam, gravelly loam, loam.	CL	A-4, A-6	0-5	80-100	75-95	70-95	55-75	25-40	5-15
92----------------- Marcus	0-16	Silty clay loam	MH, CH	A-7	0	100	100	95-100	90-100	50-65	20-35
	16-40	Silty clay loam, silty clay.	CH, MH	A-7	0	100	100	95-100	90-100	50-65	20-35
	40-59	Silt loam-------	CL	A-7	0	100	100	95-100	85-95	40-50	20-30
	59-70	Loam------------	CL	A-6	0-5	90-100	85-100	80-90	50-75	30-40	15-25

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
133----------------	0-20	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
Colo	20-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
202----------------	0-19	Clay loam-------	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
Cylinder	19-31	Loam, clay loam, sandy loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	31-60	Gravelly sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
203----------------	0-19	Silty clay loam	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
Cylinder	19-31	Loam, clay loam	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	31-60	Gravelly coarse sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
259----------------	0-18	Clay loam, silty clay loam.	CL, ML	A-7, A-6	0	95-100	95-100	70-90	50-75	35-50	10-25
Biscay	18-37	Loam, clay loam	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	37-60	Gravelly loamy sand, loamy sand.	SP-SM SM	A-1, A-2, A-3	0-5	75-95	70-95	20-55	5-25	---	NP
282----------------	0-14	Silty clay loam	MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
Ransom	14-28	Silty clay loam, silt loam.	CL	A-6, A-7	0	100	85-100	95-100	90-100	40-50	15-20
	28-60	Silt loam, loam, clay loam.	CL	A-4, A-6	0-5	95-100	85-100	75-95	55-80	30-40	10-20
310, 310B, 310C2---	0-11	Silty clay loam	ML, CL, MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
Galva	11-31	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	31-60	Silt loam, silty clay loam.	CL	A-6, A-7	0	100	100	95-100	85-100	35-50	15-25
311, 311B----------	0-12	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
Galva	12-35	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	35-55	Silt loam-------	CL	A-6, A-7	0	100	100	95-100	90-100	35-50	15-25
	55-60	Sand and gravel	SP-SM, SM	A-1	11-56	75-95	70-90	20-40	5-25	---	NP
433D, 433E, 433F, 433G--------------	0-12	Loam------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
Storden	12-60	Loam, clay loam	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
474B, 474C---------	0-11	Loam------------	CL, ML	A-4, A-6	0	100	100	85-95	50-70	30-40	5-15
Bolan	11-22	Loam------------	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	100	80-90	40-55	25-35	5-15
	22-35	Fine sandy loam, sandy loam.	SM, SM-SC, SC	A-4	0	100	100	80-90	35-50	15-25	2-8
	35-72	Loamy fine sand, fine sand, loamy sand.	SM, SP-SM	A-2	0	100	100	70-85	10-30	---	NP
485----------------	0-28	Loam------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
Spillville	28-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
505----------------	0-15	Silty clay loam, silt loam.	CL	A-6	0	100	100	100	95-100	30-40	10-20
Sperry	15-34	Silty clay loam, silty clay.	CH	A-7	0	100	100	100	95-100	50-65	25-35
	34-60	Silty clay loam, silt loam.	CL	A-7	0	100	100	100	95-100	40-50	20-30

TABLE 14.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
577C2---------------- Everly	0-7	Clay loam,------	CL	A-6, A-7	0	100	95-100	85-95	65-80	30-45	10-20
	7-26	Clay loam, loam	CL	A-6, A-7	0	95-100	95-100	85-95	70-90	35-50	15-25
	26-60	Loam, clay loam	CL	A-6	0-5	90-100	85-95	75-85	60-80	30-40	10-20
577D---------------- Everly	0-12	Clay loam-------	CL	A-6, A-7	0	100	95-100	85-95	65-80	30-45	10-20
	12-28	Clay loam, loam	CL	A-6, A-7	0	95-100	95-100	85-95	70-90	35-50	15-25
	28-60	Loam, clay loam	CL	A-6	0-5	90-100	85-95	75-85	60-80	30-40	10-20
639G: Storden-----------	0-7	Loam------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	7-60	Loam------------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
Salida------------	0-9	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	9-60	Gravelly loamy sand, gravelly coarse sand, gravelly loamy coarse sand.	SP, SW, GP, GP-GM	A-1	0-5	50-90	40-60	10-30	0-5	---	NP
708B, 708C2, 709, 709B-------------- Fairhaven	0-8	Silt loam-------	ML, CL	A-4, A-6	0	100	95-100	95-100	70-95	35-50	15-25
	8-36	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6	0	100	95-100	95-100	70-90	25-40	10-25
	36-60	Stratified coarse sandy loam to gravel.	SP, SP-SM	A-1	0-5	70-100	50-100	20-50	1-10	---	NP
733---------------- Calco	0-48	Silty clay loam	ML, MH, CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	48-60	Silty clay loam, loam, clay loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
785---------------- Spillco	0-42	Loam------------	CL	A-6	0	100	95-100	85-95	55-80	25-40	10-20
	42-60	Sandy loam, loam, silt loam.	CL-ML, CL, SM-SC, SC	A-4, A-6	0	95-100	90-95	70-85	35-75	15-30	5-15
878B--------------- Ocheyedan	0-29	Loam------------	CL	A-6	0	100	95-100	75-90	65-80	30-40	10-15
	29-34	Sandy clay loam, fine sandy loam, loam.	SC, CL, SM-SC, CL-ML	A-4, A-6	0	100	95-100	60-80	35-55	25-40	5-15
	34-60	Sandy loam, sandy clay loam, silt loam.	CL-ML, CL	A-4, A-6	0	100	95-100	85-95	50-90	25-40	5-15
1658C: Terril------------	0-33	Loam------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	33-60	Clay loam-------	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
Colo--------------	0-20	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	20-60	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
1785--------------- Spillco	0-60	Loam------------	CL, CL-ML	A-6, A-4	0	100	95-100	85-95	55-80	25-40	5-15
5010. Pits											
5040. Orthents											

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay <2mm	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
26---------------- Kennebec	0-31	26-30	1.25-1.35	0.6-2.0	0.22-0.24	6.1-7.3	Moderate-----	0.32	5	6	5-6
	31-60	24-28	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Moderate-----	0.43			
27B, 27C--------- Terril	0-33	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	5	6	4-5
	33-60	27-32	1.45-1.70	0.6-2.0	0.16-0.18	6.1-8.4	Low----------	0.32			
31---------------- Afton	0-26	33-38	1.25-1.30	0.6-2.0	0.21-0.23	6.6-7.8	High---------	0.28	5	4	6-7
	26-51	25-35	1.25-1.30	0.6-2.0	0.18-0.20	7.4-8.4	High---------	0.43			
	51-60	25-30	1.30-1.45	0.6-2.0	0.14-0.16	7.9-8.4	High---------	0.43			
32---------------- Spicer	0-19	30-36	1.20-1.30	0.6-2.0	0.18-0.24	7.4-8.4	High---------	0.28	5	5	6-7
	19-38	26-34	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Moderate-----	0.28			
	38-60	18-35	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Low----------	0.28			
72B, 72D--------- Estherville	0-13	10-18	1.35-1.45	2.0-6.0	0.16-0.18	5.6-7.3	Low----------	0.20	3	5	2-3
	13-25	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low----------	0.20			
	25-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low----------	0.10			
73E, 73F--------- Salida	0-9	5-15	1.35-1.45	6.0-20	0.10-0.12	6.6-8.4	Low----------	0.10	3	8	.5-1
	9-60	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
77B--------------- Sac	0-12	32-37	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.32	5-4	4	3-4
	12-31	24-32	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.43			
	31-60	22-30	1.60-1.80	0.6-2.0	0.14-0.16	6.6-8.4	Moderate-----	0.43			
77C2-------------- Sac	0-7	32-37	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.32	5-4	4	2-3
	7-28	24-32	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.43			
	28-60	22-30	1.60-1.80	0.6-2.0	0.14-0.16	6.6-8.4	Moderate-----	0.43			
89B, 89C2-------- Sac Variant	0-11	32-37	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.32	5-4	4	2-4
	11-28	24-32	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.43			
	28-60	20-30	1.35-1.45	0.6-2.0	0.19-0.21	7.4-8.4	Low----------	0.32			
91, 91B---------- Primghar	0-17	35-39	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.28	5	4	5-6
	17-35	30-35	1.30-1.35	0.6-2.0	0.18-0.20	6.1-8.4	High---------	0.43			
	35-44	25-30	1.35-1.40	0.6-2.0	0.20-0.22	7.9-8.4	Moderate-----	0.43			
	44-60	22-30	1.60-1.80	0.6-2.0	0.14-0.19	7.9-8.4	Low----------	0.43			
92---------------- Marcus	0-16	34-40	1.30-1.35	0.2-0.6	0.21-0.23	6.1-7.8	High---------	0.28	5	4	6-7
	16-40	30-40	1.35-1.40	0.6-2.0	0.18-0.20	6.1-8.4	High---------	0.43			
	40-59	25-30	1.35-1.45	0.6-2.0	0.20-0.22	7.9-8.4	Moderate-----	0.43			
	59-70	22-30	1.60-1.80	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.43			
133--------------- Colo	0-20	27-32	1.28-1.32	0.6-2.0	0.21-0.23	6.6-7.3	High---------	0.28	5	7	5-7
	20-60	32-36	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
202, 203--------- Cylinder	0-19	22-32	1.40-1.45	0.6-2.0	0.20-0.22	6.1-7.3	Moderate-----	0.24	4	6	4-5
	19-31	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	31-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
259--------------- Biscay	0-18	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate-----	0.28	4	6	5-7
	18-37	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate-----	0.28			
	37-60	10-28	1.35-1.55	2.0-6.0	0.11-0.17	6.6-7.8	Low----------	0.28			
282--------------- Ransom	0-14	32-38	1.20-1.30	0.6-2.0	0.18-0.22	5.6-7.3	High---------	0.32	5	7	5-6
	14-21	20-36	1.25-1.35	0.6-2.0	0.16-0.19	6.6-7.8	High---------	0.43			
	21-60	18-30	1.40-1.70	0.2-0.6	0.20-0.22	7.4-8.4	Low----------	0.43			
310, 310B, 310C2- Galva	0-11	34-37	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.32	5-4	7	2-4
	11-31	30-36	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.43			
	31-60	25-30	1.35-1.45	0.6-2.0	0.20-0.22	6.6-8.4	Moderate-----	0.43			

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
311, 311B-------- Galva	0-12	34-39	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate-----	0.32	5	7	3-4
	12-35	30-39	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate-----	0.43			
	35-55	25-27	1.35-1.45	0.6-2.0	0.20-0.22	6.6-8.4	Moderate-----	0.43			
	55-60	2-8	1.60-1.75	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
433D, 433E, 433F, 433G------------ Storden	0-12	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	1-2
	12-60	18-27	1.30-1.45	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
474B, 474C------- Bolan	0-11	16-22	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	4	6	2-3
	11-22	14-20	1.45-1.50	0.6-2.0	0.17-0.19	5.6-7.3	Low----------	0.28			
	22-35	10-15	1.50-1.60	2.0-6.0	0.11-0.13	5.6-6.5	Low----------	0.28			
	35-60	2-8	1.60-1.70	>20	0.08-0.10	5.6-7.3	Low----------	0.17			
485-------------- Spillville	0-28	18-26	1.45-1.55	0.6-2.0	0.19-0.21	6.1-7.3	Moderate-----	0.28	5	6	5-6
	28-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	6.1-8.4	Low----------	0.28			
505-------------- Sperry	0-15	28-34	1.35-1.40	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.28	5	6	4-5
	15-34	38-45	1.40-1.45	<0.2	0.14-0.16	5.1-6.5	High---------	0.43			
	34-60	26-34	1.45-1.50	0.2-0.6	0.19-0.21	5.6-6.5	High---------	0.43			
577C2, 577D------ Everly	0-12	25-30	1.40-1.45	0.6-2.0	0.17-0.19	5.6-7.3	Moderate-----	0.24	5	6	2-4
	12-23	25-35	1.45-1.55	0.6-2.0	0.15-0.17	6.1-7.3	Moderate-----	0.32			
	23-60	22-32	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.32			
639G:											
Storden---------	0-7	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	1-2
	7-60	18-27	1.30-1.45	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
Salida----------	0-9	5-15	1.35-1.45	2.0-6.0	0.10-0.12	6.1-8.4	Low----------	0.10	3	8	.5-1
	9-60	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
708B, 708C2, 709, 709B------------ Fairhaven	0-8	18-30	1.25-1.40	0.6-2.0	0.22-0.24	6.1-7.3	Low----------	0.32	4	6	2-4
	8-36	18-30	1.30-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.43			
	36-60	0-5	1.55-1.65	6.0-20	0.02-0.04	6.1-8.4	Low----------	0.10			
733-------------- Calco	0-48	28-33	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High---------	0.28	5	7	5-7
	48-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate-----	0.28			
785-------------- Spillco	0-42	20-26	1.45-1.55	0.6-2.0	0.19-0.21	6.6-8.4	Low----------	0.24	5	6	5-6
	42-60	14-28	1.55-1.70	2.0-6.0	0.14-0.19	7.9-8.4	Low----------	0.24			
878B------------- Ocheyedan	0-29	22-27	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.24	5	6	3-4
	29-34	14-24	1.45-1.60	0.6-6.0	0.16-0.18	6.1-7.3	Low----------	0.32			
	34-60	12-24	1.45-1.70	0.6-2.0	0.19-0.21	6.6-8.4	Low----------	0.32			
1658C:											
Terril----------	0-33	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	5	6	4-5
	33-60	27-32	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low----------	0.32			
Colo------------	0-20	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	High---------	0.28	5	7	5-7
	20-60	32-36	1.25-1.35	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28			
1785------------- Spillco	0-60	14-24	1.45-1.55	0.6-2.0	0.19-0.21	7.4-8.4	Low----------	0.24	5	6	2-3
5010. Pits											
5040. Orthents											

TABLE 16.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "brief," "frequent," and "apparent" are explained in the text. The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
26----------------- Kennebec	B	Occasional	Brief-----	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	High-----	Moderate	Low.
27B, 27C---------- Terril	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
31----------------- Afton	C/D	Frequent----	Very brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
32----------------- Spicer	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-May	High-----	High-----	Low.
72B, 72D---------- Estherville	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
73E, 73F---------- Salida	A	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
77B, 77C2--------- Sac	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
89B, 89C2--------- Sac Variant	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
91, 91B----------- Primghar	B	None--------	---	---	3.0-5.0	Apparent	Nov-Jul	High-----	Moderate	Moderate.
92----------------- Marcus	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
133---------------- Colo	B/D	Frequent----	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
202, 203---------- Cylinder	B	None--------	---	---	3.0-5.0	Apparent	Nov-Jul	High-----	Moderate	Low.
259---------------- Biscay	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	Moderate	Low.
282---------------- Ransom	B	None--------	---	---	3.0-5.0	Apparent	Apr-Jun	High-----	High-----	Low.
310, 310B, 310C2, 311, 311B-------- Galva	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Moderate.
433D, 433E, 433F, 433G------------ Storden	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
474B, 474C-------- Bolan	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
485---------------- Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
505---------------- Sperry	C/D	Frequent----	Very brief to long.	Feb-Nov	0-1.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
577C2, 577D------- Everly	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
639G:										
Storden----------	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
639G: Salida	A	None	---	---	>6.0	---	---	Low	Low	Low.
708B, 708C2, 709, 709B Fairhaven	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
733 Calco	B/D	Frequent	Brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
785 Spillco	B	Frequent	Very brief to brief.	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	High	Moderate	Low.
878B Ocheyedan	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
1658C: Terril	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
Colo	B/D	Frequent	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Moderate.
1785 Spillco	B	Frequent	Brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	Moderate	Low.
5010. Pits										
5040. Orthents										

TABLE 17.--ENGINEERING TEST DATA

Soil name, report number, horizon, and depth in inches	Classification		Grain size distribution							Liquid limit	Plasticity index	Moisture density	
			Percentage passing sieve--				Percentage smaller than--						
	AASHTO	Unified	No. 4	No. 10	No. 40	No. 200	.02 mm	.005 mm	.002 mm			Max. dry density	Optimum moisture
										Pct		Lb/ft3	Pct
Galva silty clay loam:[1] (S73IA-071-033)													
Ap------- 0 to 6	A-7-6(20)	ML	100	100	100	98	65	39	28	45	17	94	24
B21-B22--17 to 23	A-7-6(27)	CL	100	100	100	99	68	43	33	48	24	100	21
C--------45 to 50	A-6 (17)	CL	100	100	100	99	54	31	24	37	16	106	18
Primghar silty clay loam:[2] (S73IA-071-034)													
Ap-A12--- 0 to 11	A-7-6(25)	CL	100	100	100	99	64	43	34	48	21	92	26
B21-B22--17 to 35	A-7-6(22)	CL	100	100	100	98	63	38	31	45	20	102	20
IIC2-----49 to 60	A-6 (06)	CL	100	99	96	71	40	34	28	29	11	115	14
Sac silty clay loam:[3] (S73IA-071-004)													
Ap------- 0 to 7	A-7-6(24)	CL	100	100	100	98	60	39	30	47	21	95	24
B22------18 to 25	A-7-6(22)	CL	100	100	100	99	58	38	29	42	20	102	20
IIC------36 to 60	A-6 (08)	CL	100	99	97	75	55	36	25	30	13	106	18

[1]Galva silty clay loam:
1.8 miles southwest of Paulina, 1,060 feet west and 190 feet south of the northeast corner of sec. 18, T. 94 N., R. 41 W.

[2]Primghar silty clay loam:
3.3 miles west of Hartley, 1,770 feet west and 480 feet north of the southeast corner of sec. 34, T. 97 N., R. 40 W.

[3]Sac silty clay loam:
4.7 miles northwest of Sanborn, 1,790 feet east and 55 feet south of the northwest corner of sec. 16, T. 97 N., R. 41 W.

TABLE 18.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Afton	Fine-silty, mixed, mesic Cumulic Haplaquolls
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Bolan	Coarse-loamy, mixed, mesic Typic Hapludolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Estherville	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Everly	Fine-loamy, mixed, mesic Typic Hapludolls
Fairhaven	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Galva	Fine-silty, mixed, mesic Typic Hapludolls
*Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Marcus	Fine-silty, mixed, mesic Typic Haplaquolls
Ocheyedan	Fine-loamy, mixed, mesic Typic Hapludolls
Orthents	Fine-loamy, mixed, mesic Udorthents
Primghar	Fine-silty, mixed, mesic Aquic Hapludolls
Ransom	Fine-silty, mixed, mesic Aquic Hapludolls
Sac	Fine-silty, mixed, mesic Typic Hapludolls
Sac Variant	Fine-silty, mixed, mesic Typic Hapludolls
*Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
*Sperry	Fine, montmorillonitic, mesic Typic Argialbolls
Spicer	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Spillco	Fine-loamy, mixed, mesic Cumulic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
*Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls

*The soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series.

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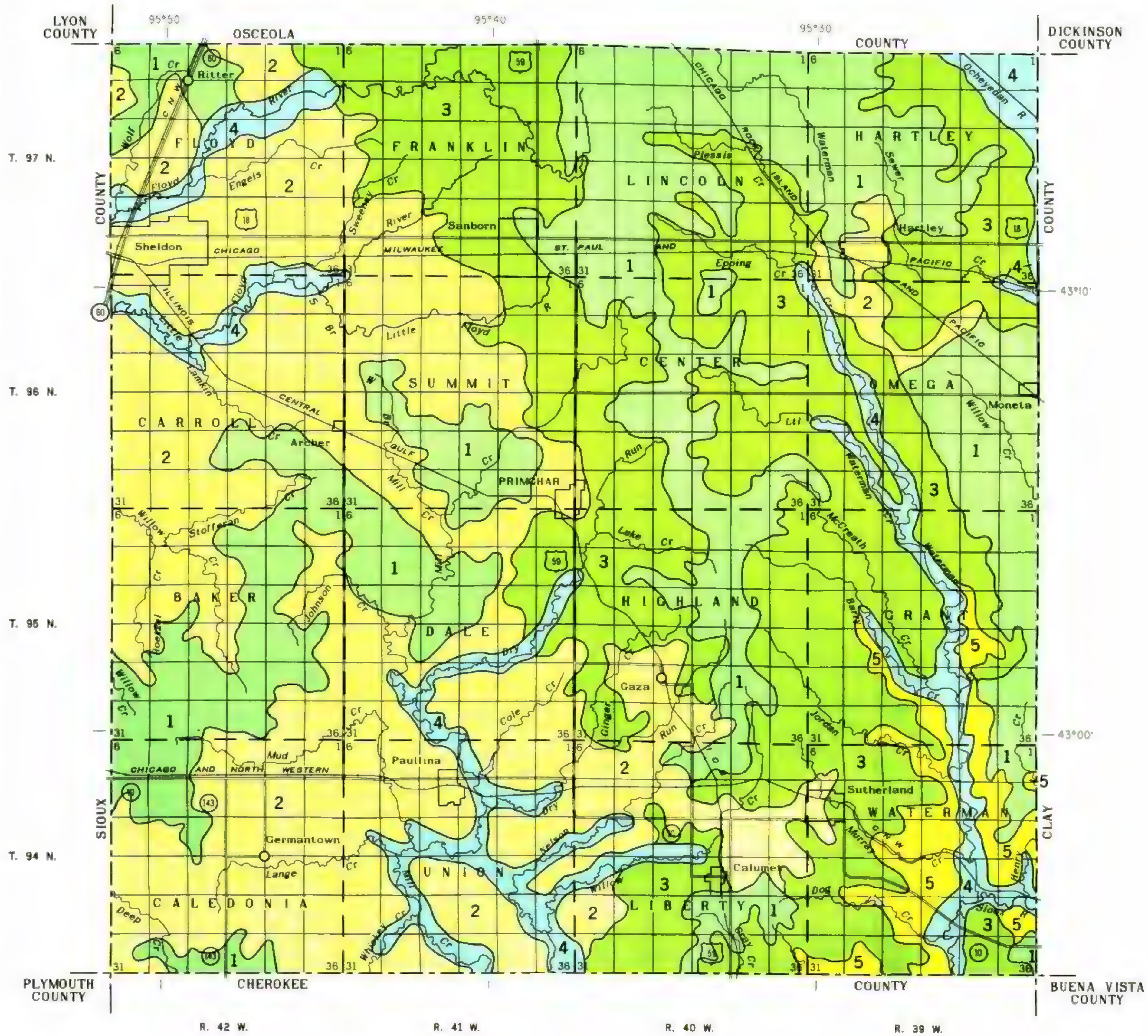
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY
DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

GENERAL SOIL MAP
O'BRIEN COUNTY, IOWA

Scale 1:190,080



SOIL LEGEND*

1	Primghar-Marcus-Galva association: Level to gently sloping, somewhat poorly drained, poorly drained, and well drained silty soils that formed in loess; on uplands
2	Galva-Primghar association: Level to gently sloping, well drained and somewhat poorly drained silty soils that formed in loess; on uplands
3	Sac-Galva-Primghar association: Level to moderately sloping, well drained and somewhat poorly drained silty soils that formed in loess and the underlying glacial till; on uplands
4	Calco-Colo-Galva association: Level to gently sloping, poorly drained and well drained silty soils that formed in loess and alluvium; on bottom lands and stream benches
5	Storden-Galva-Sac association: Level to very steep, well drained silty and loamy soils that formed in loess and glacial till; on uplands

*The terms for texture in the descriptive statements apply to the surface layer of the major soils in each association.

Compiled 1979

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

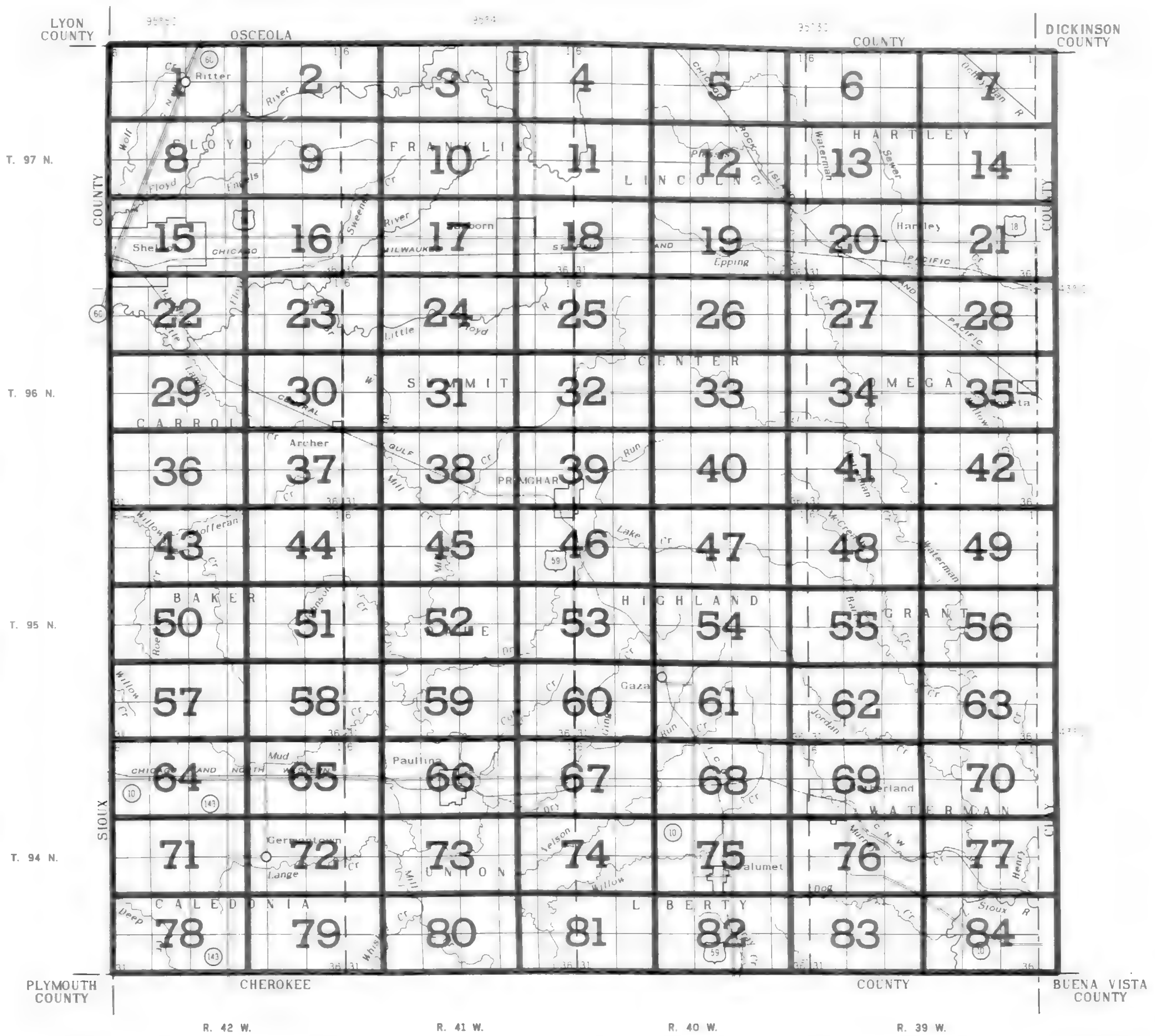
INDEX TO MAP SHEETS

O'BRIEN COUNTY, IOWA

Scale 1:190,080

1 0 1 2 3 4 Miles

1 0 1 2 3 4 5 6 Kilometers



Original text from each individual map sheet read:
This map is compiled on 1976 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool

Davis Airstrip

FLOOD POOL LINE

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate
- Federal
- State
- County, farm or ranch

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — GAS
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial
- Intermittent

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — 77B 310

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown)

MISCELLANEOUS

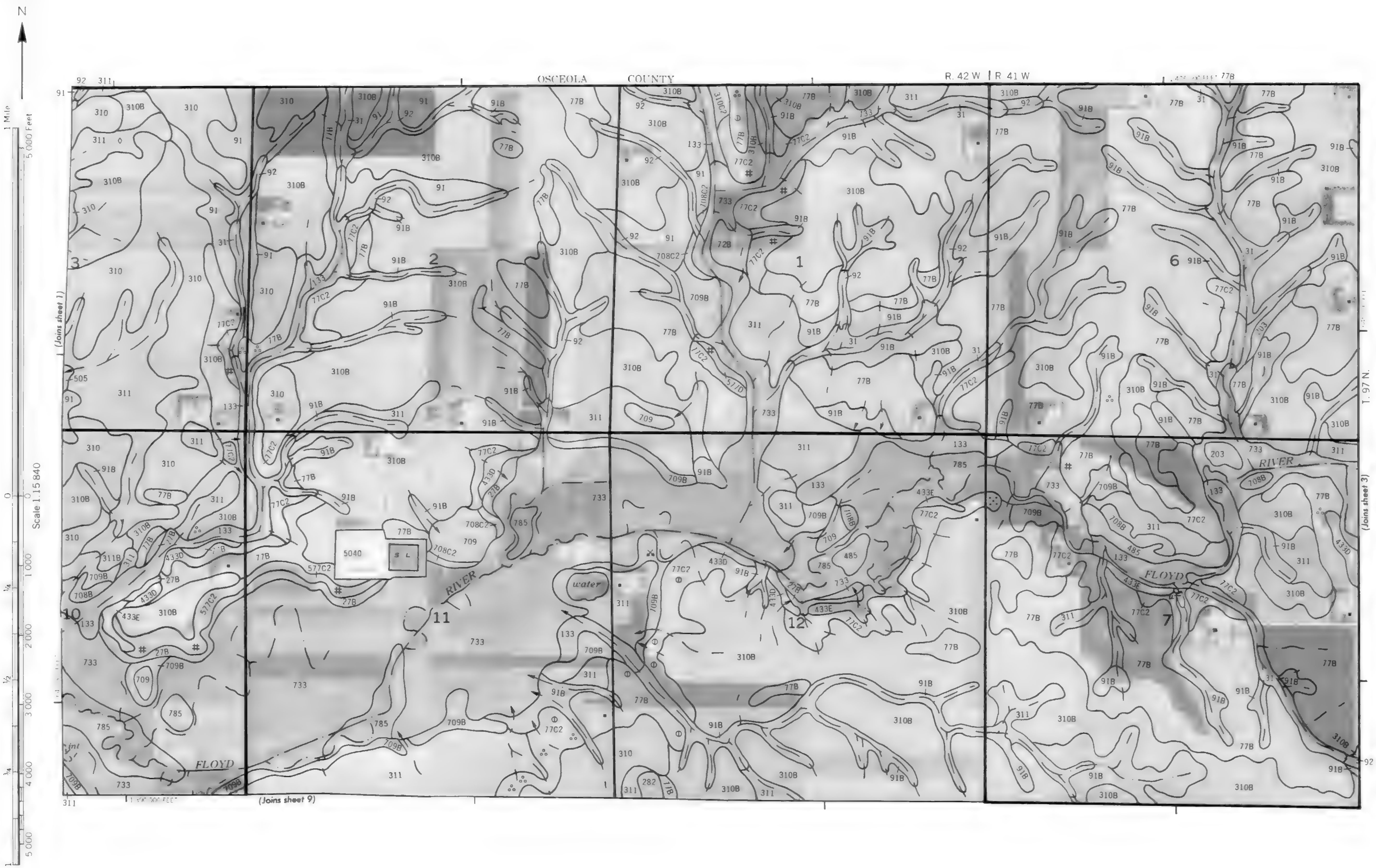
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Calcareous spot
- Sandy or gravelly substratum spot
- Clayey subsoil spot
- Glacial till outcrop spot
- Sewage lagoon — S.L.

SOIL LEGEND

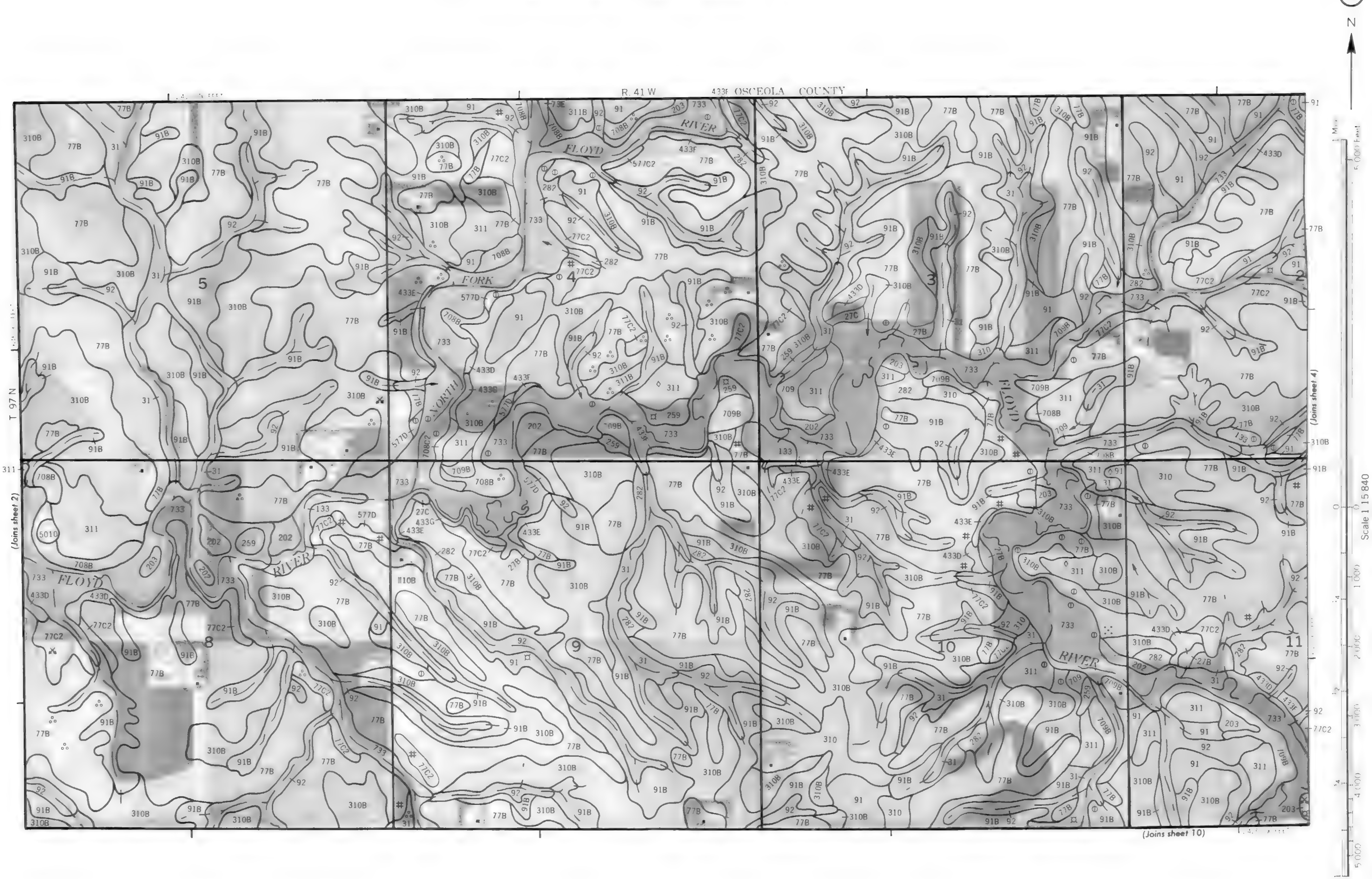
Map symbols consist of numbers or a combination of numbers and letters. The initial numbers represent the kind of soil. A capital letter following the numbers indicates the class of slope. Symbols without a slope letter are for nearly level soils or miscellaneous areas. A final number of 2 following the slope letter indicates that the soil is moderately eroded.

SYMBOL	NAME
	Kennebec silty clay loam, 0 to 2 percent slopes
27B	Terril loam, 2 to 5 percent slopes
27C	Terril loam, 5 to 14 percent slopes
31	Afton silty clay loam, 0 to 2 percent slopes
32	Spicer silty clay loam, 0 to 2 percent slopes
72B	Estherville loam, 1 to 4 percent slopes
72D	Estherville loam, 5 to 14 percent slopes
73E	Salida sandy loam, 9 to 18 percent slopes
73F	Salida sandy loam, 18 to 40 percent slopes
77B	Sac silty clay loam, 2 to 5 percent slopes
77C2	Sac silty clay loam, 5 to 9 percent slopes, moderately eroded
89B	Sac Variant silty clay loam, 2 to 5 percent slopes
89C2	Sac Variant silty clay loam, 5 to 9 percent slopes, moderately eroded
91	Primghar silty clay loam, 0 to 2 percent slopes
91B	Primghar silty clay loam, 2 to 4 percent slopes
92	Marcus silty clay loam, 0 to 2 percent slopes
133	Colo silty clay loam, 0 to 2 percent slopes
202	Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
203	Cylinder silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
282	Ransom silty clay loam, 1 to 3 percent slopes
310	Galva silty clay loam, 0 to 2 percent slopes
310B	Galva silty clay loam, 2 to 5 percent slopes
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded
311	Galva silty clay loam, stratified substratum, 0 to 2 percent slopes
311B	Galva silty clay loam, stratified substratum, 2 to 5 percent slopes
433D	Storden loam, 9 to 14 percent slopes
433E	Storden loam, 14 to 18 percent slopes
433F	Storden loam, 18 to 25 percent slopes
433G	Storden loam, 25 to 40 percent slopes
474B	Bolan loam, 2 to 5 percent slopes
474C	Bolan loam, 5 to 14 percent slopes
485	Spillville loam, 0 to 2 percent slopes
505	Sperry silty clay loam, 0 to 1 percent slopes
577C2	Everly clay loam, 5 to 9 percent slopes, moderately eroded
577D	Everly clay loam, 9 to 14 percent slopes
639G	Storden—Salida complex, 25 to 40 percent slopes
708B	Fairhaven silt loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
708C2	Fairhaven silt loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded
709	Fairhaven silt loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
709B	Fairhaven silt loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
733	Calco silty clay loam, 0 to 2 percent slopes
785	Spillco loam, 0 to 2 percent slopes
878B	Ocheyedan loam, 2 to 5 percent slopes
1658C	Terril—Colo complex, channeled, 2 to 10 percent slopes
1785	Spillco loam, channeled, 0 to 2 percent slopes
5010	Pits, gravel
5040	Orthents, loamy


N
LYON COUNTY
OSCEOLA COUNTY
R. 42 W.
T. 97 N.
SIOUX COUNTY
Ritter
CHICAGO AND NORTH WESTERN
Wolf Creek
FLOYD RIVER
(Joins sheet 2)
(Joins sheet 8)
Scale 1:15 840
1 Mile
5 000 Feet

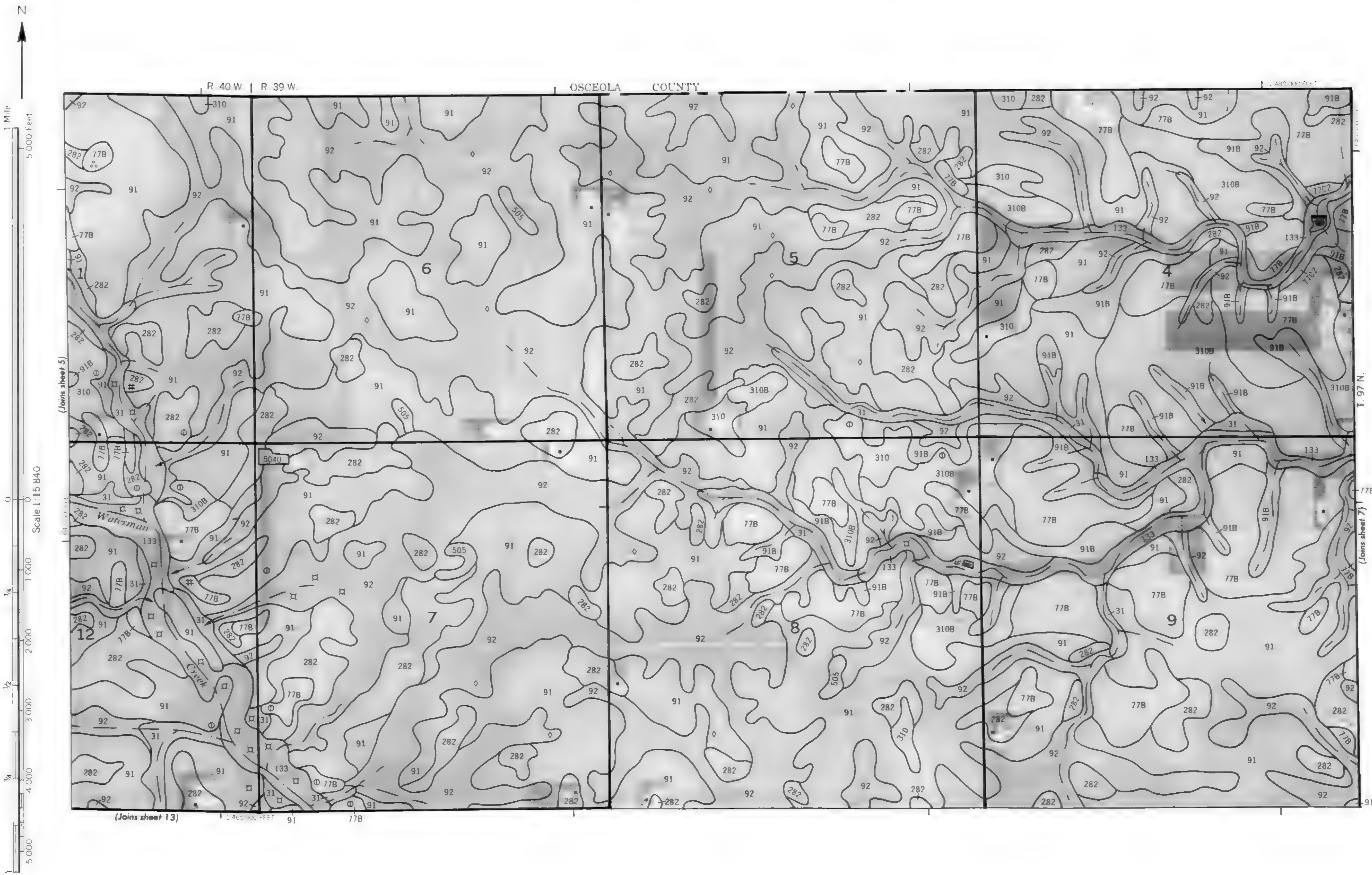


N
OSCEOLA COUNTY
R. 42 W
R. 41 W
T. 97 N.
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 9)
FLOYD
RIVER
water
1 Mile
5 000 Feet
Scale 1:15 840


3
N
R. 41 W
OSCEOLA COUNTY
T 97 N
FLOYD RIVER
NORTH FORK
FLOYD RIVER
FLOYD RIVER
5
4
3
2
8
9
10
11
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 10)
Scale 1:15 840
1 Mile
5000 Feet

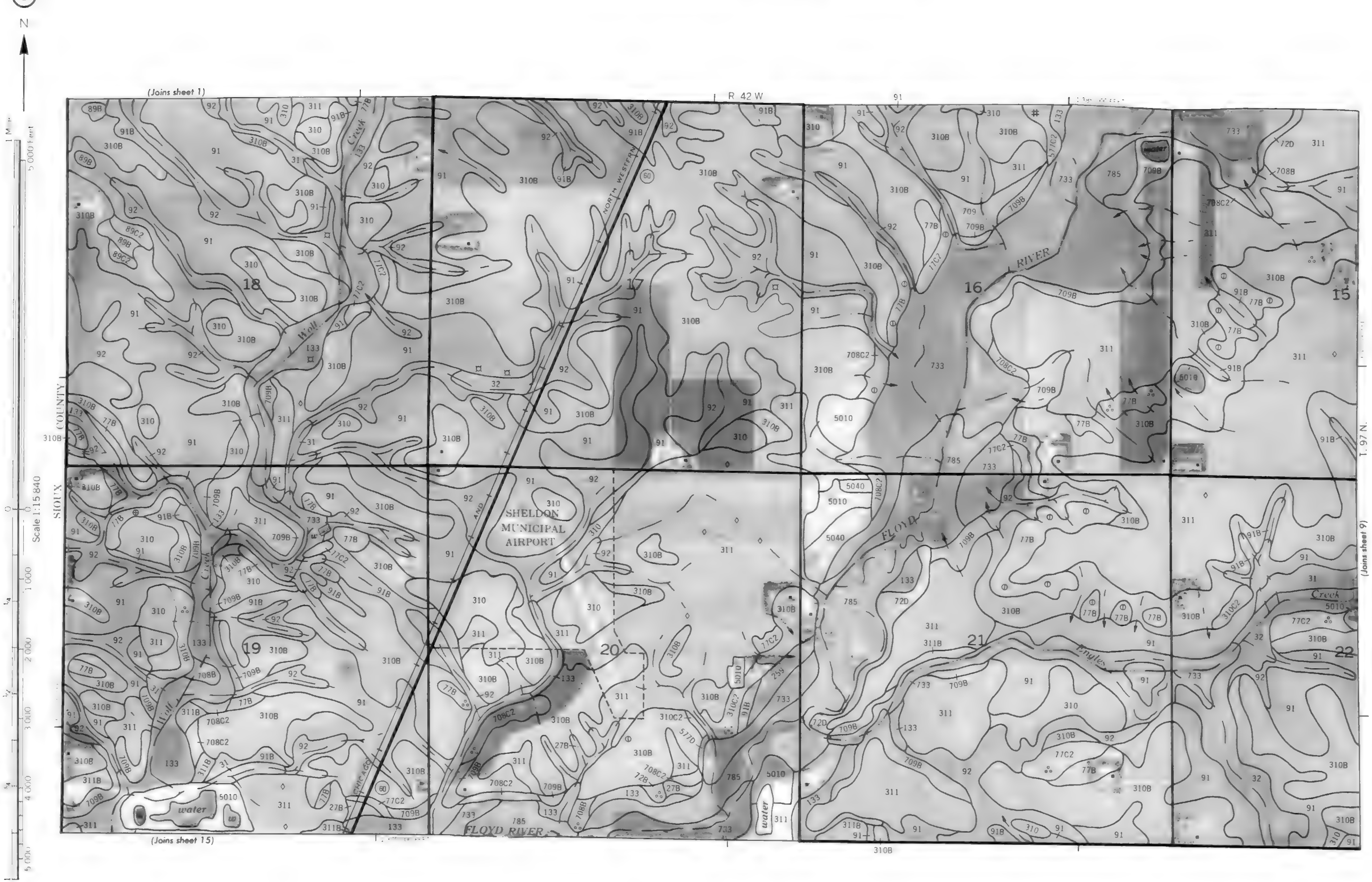

4
N
1 Mile
5 000 Feet
Scale 1:15 840
R. 41 W. | R. 40 W.
OSCEOLA COUNTY
(Joins sheet 3)
(Joins sheet 5)
(Joins sheet 11)
T. 97 N.
1
2
5
6
7
8
11
12


5
N
OSCEOLA COUNTY
R. 40 W.
T. 97 N.
(Joins sheet 4)
(Joins sheet 6)
(Joins sheet 12)
Waterman Creek
CHICAGO ROCK ISLAND AND PACIFIC
Plessis
Scale 1:15 840
5 000 Feet

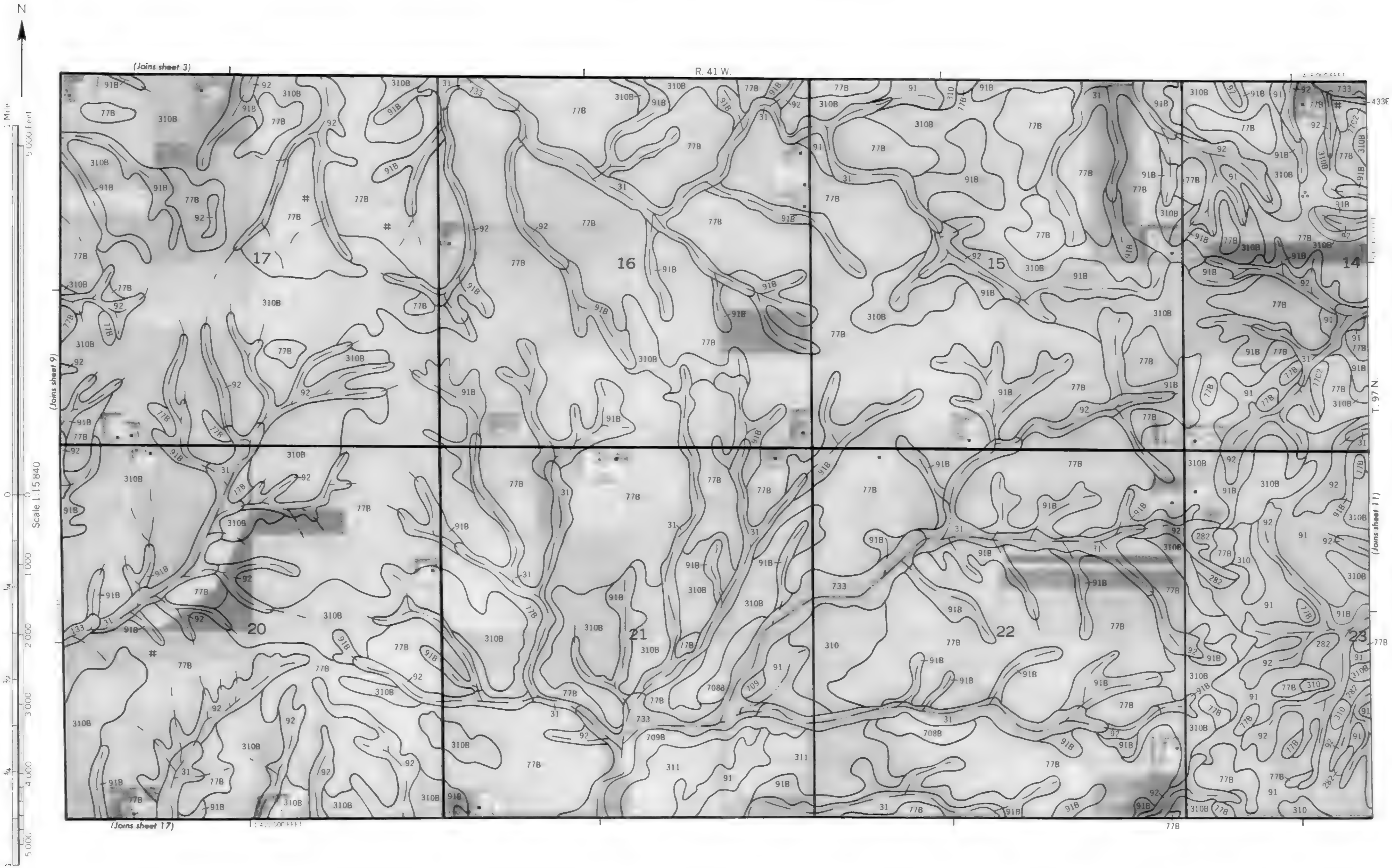

N
1 Mile
5 000 Feet
Scale 1:15 840
R. 40 W.
R. 39 W.
OSCEOLA COUNTY
T. 97 N.
(Joins sheet 5)
(Joins sheet 7)
(Joins sheet 13)
Waterman
Creek
1
4
5
6
7
8
9
12

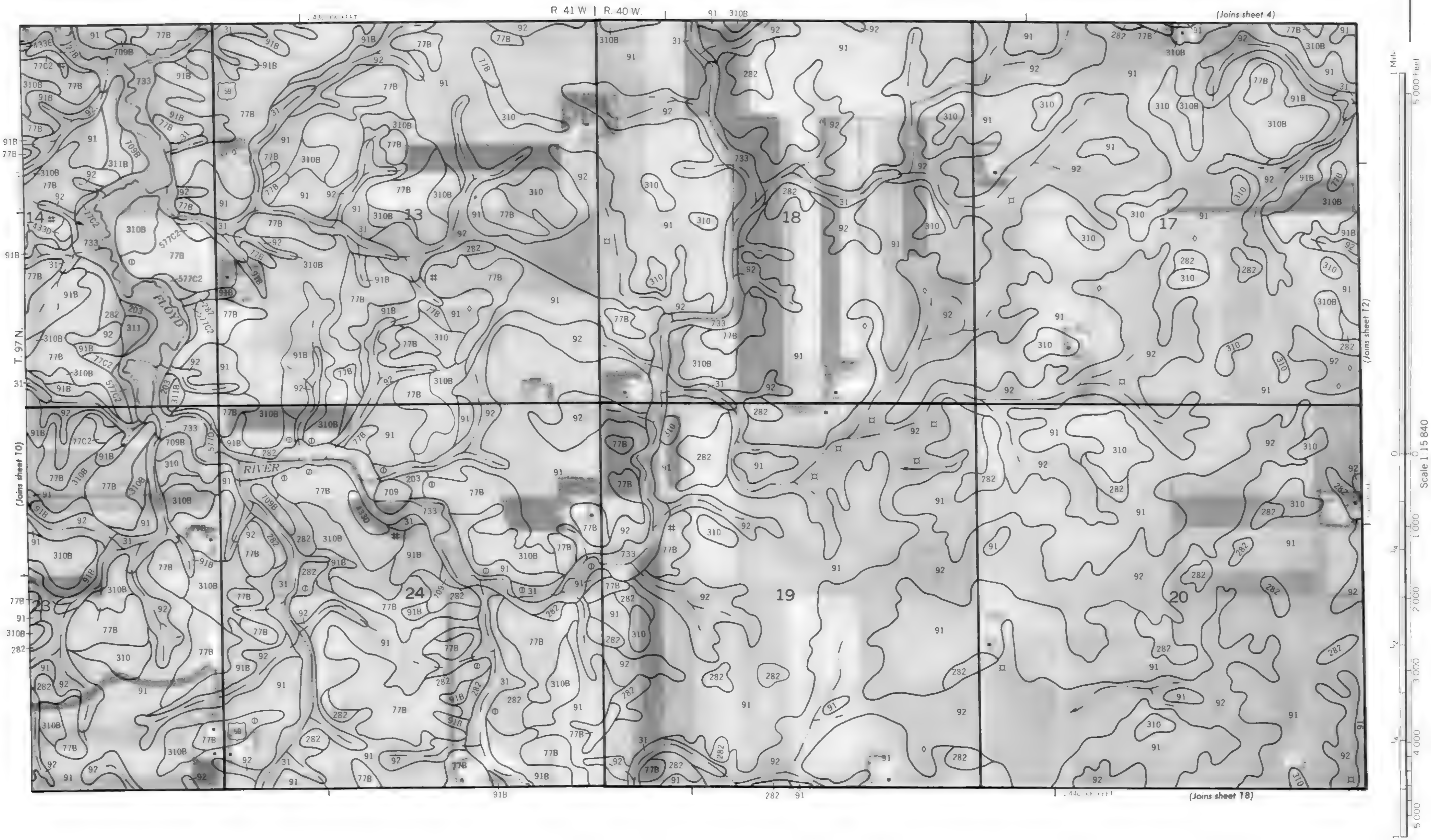

7
N
OSCEOLA COUNTY
R. 39 W.
DICKINSON COUNTY
CLAY COUNTY
T. 97 N.
OCHEYEDAN RIVER
(Joins sheet 6)
(Joins sheet 14)
1
2
3
10
11
12
1 Mile
5 000 Feet
Scale 1:15 840

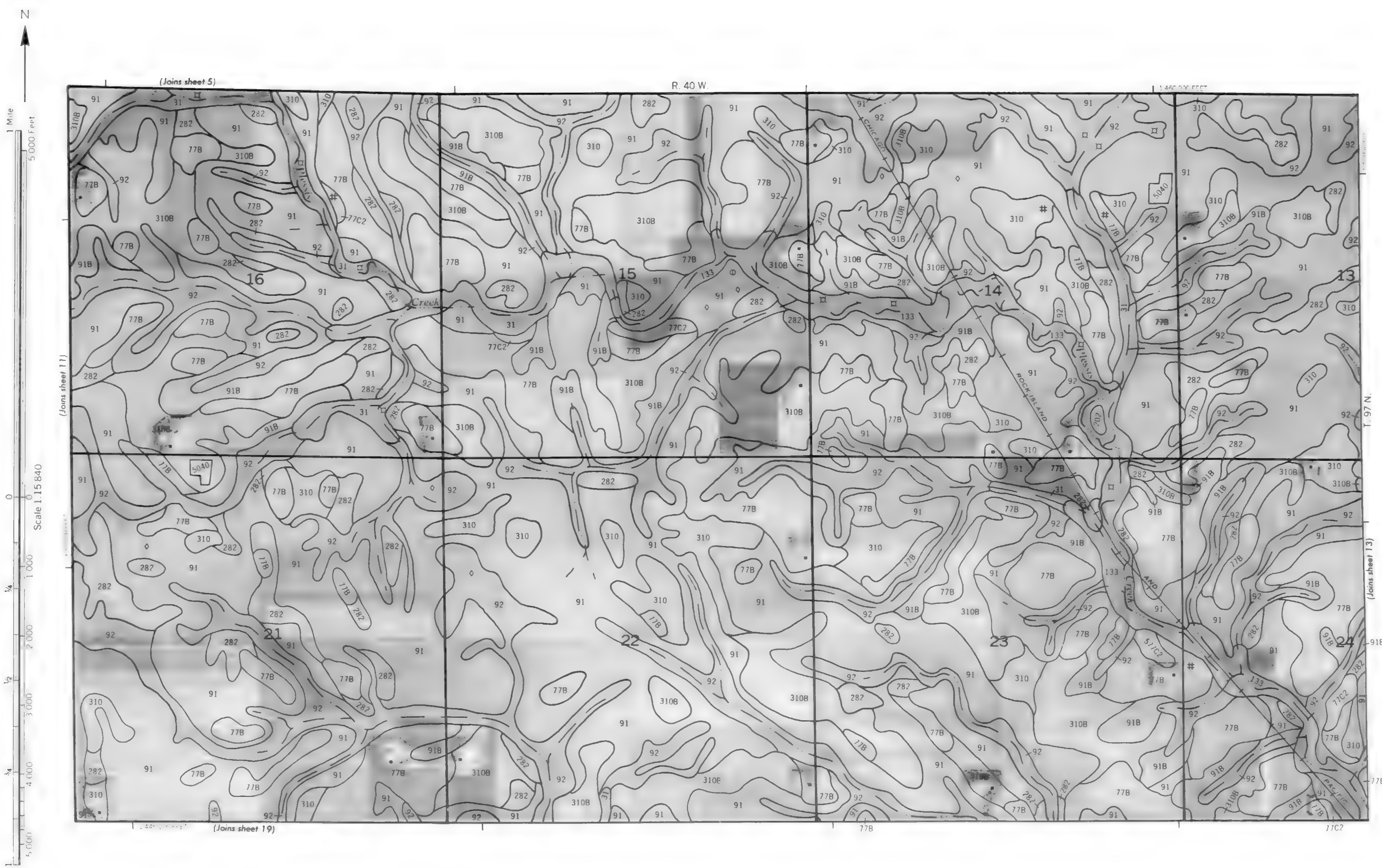
8


N
Scale 1:15 840
(Joins sheet 1)
(Joins sheet 15)
(Joins sheet 9)
R 42 W
T. 97 N.
SIOUX COUNTY
18
17
16
15
19
20
21
22
SHELDON MUNICIPAL AIRPORT
NORTH WESTERN
CHICAGO AND
FLOYD RIVER
Wolf Creek
Engles Creek
water

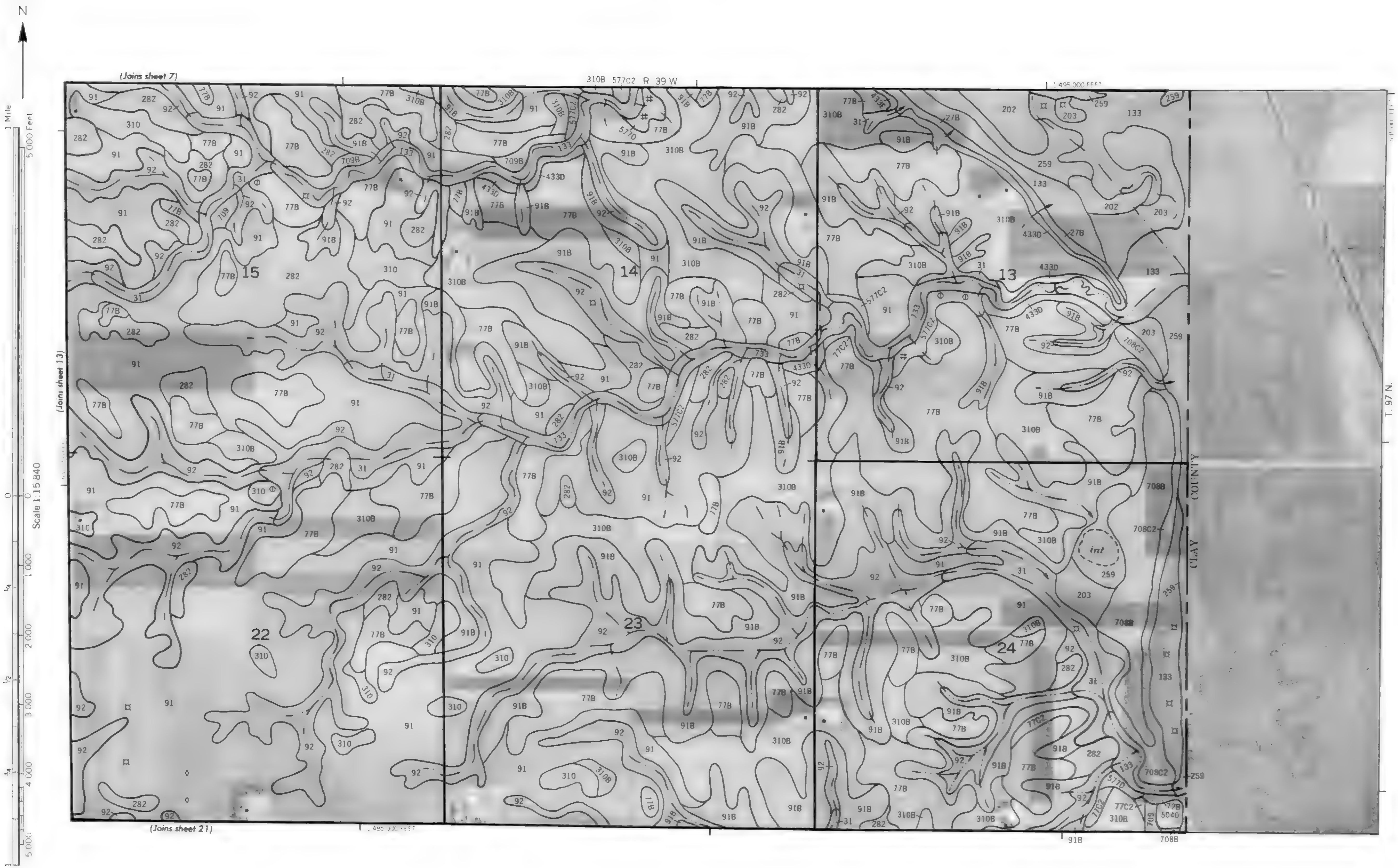

R. 42 W.
R. 41 W.
T. 97 N.
(Joins sheet 2)
(Joins sheet 10)
(Joins sheet 8)
(Joins sheet 16)
15
14
13
18
22
23
24
19
Engles
Creek
Sweeney
Creek
N
1 Mile
5 000 Feet
Scale 1:15 840

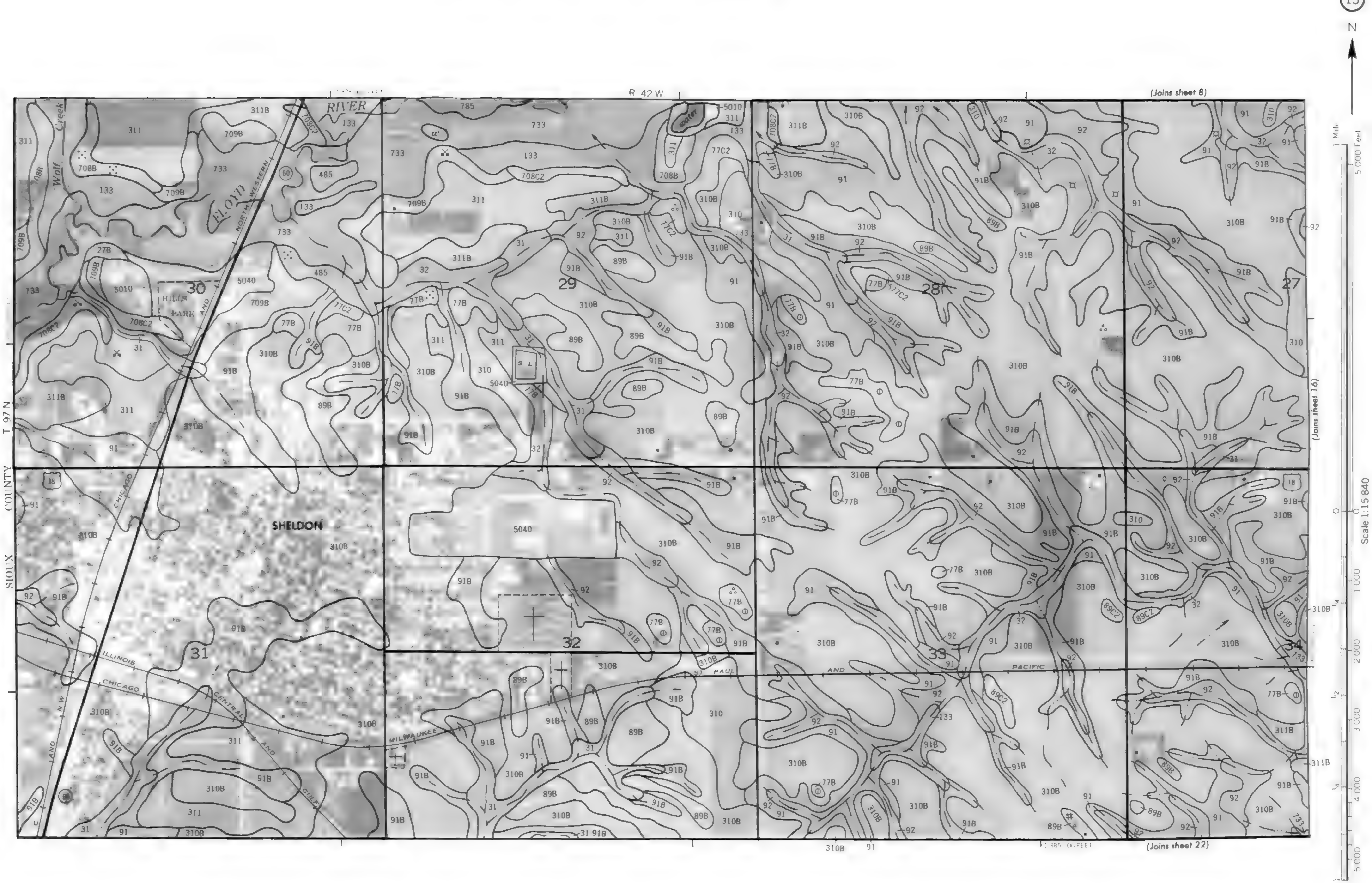

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 3)
R. 41 W.
(Joins sheet 9)
T. 97 N.
(Joins sheet 11)
(Joins sheet 17)
17
16
15
14
20
21
22
23

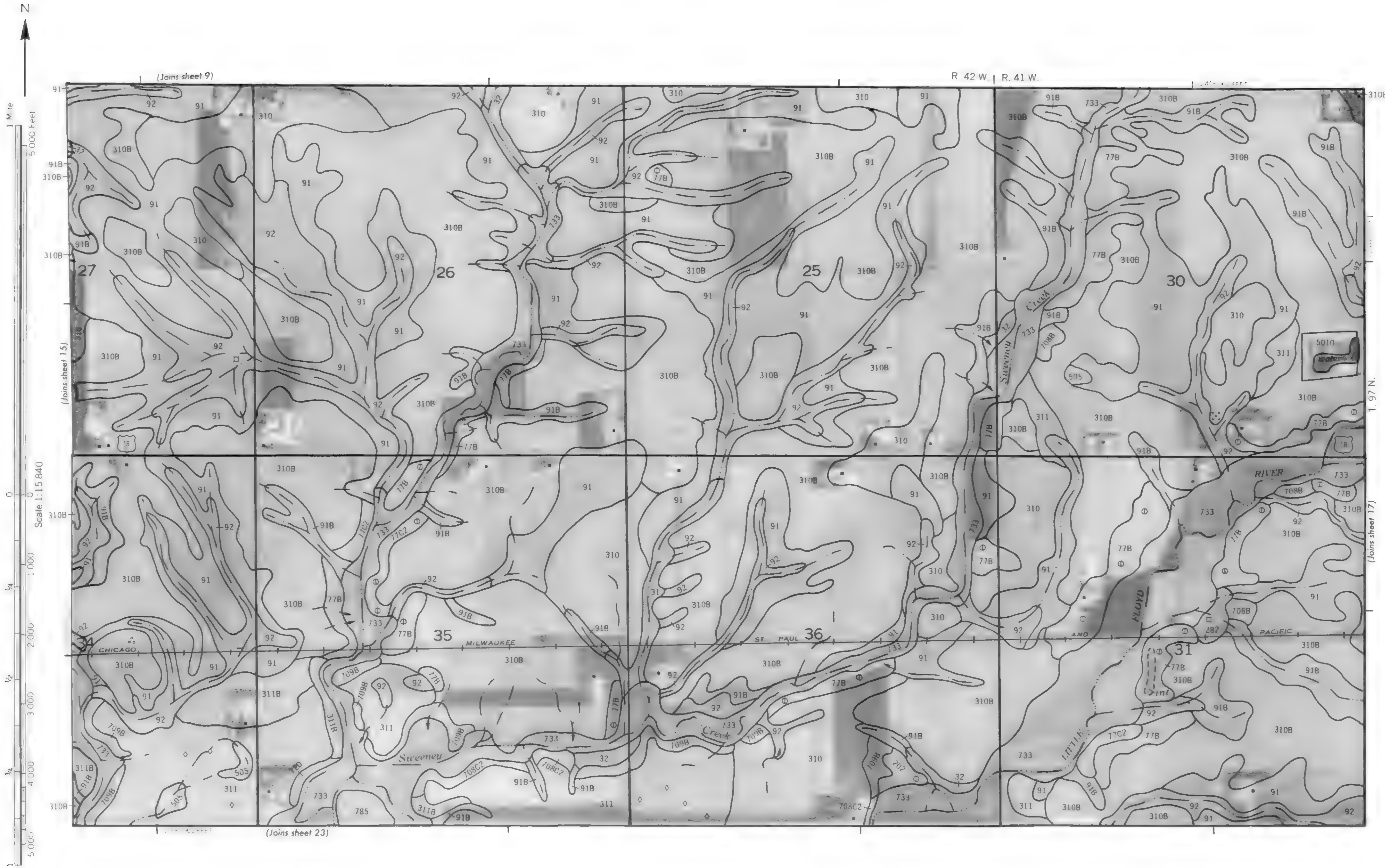

N
R 41 W | R. 40 W.
(Joins sheet 4)
(Joins sheet 12)
(Joins sheet 18)
(Joins sheet 10)
T. 97 N.
FLOYD
RIVER
14
13
18
17
23
24
19
20
1 Mile
5 000 Feet
Scale 1:15 840

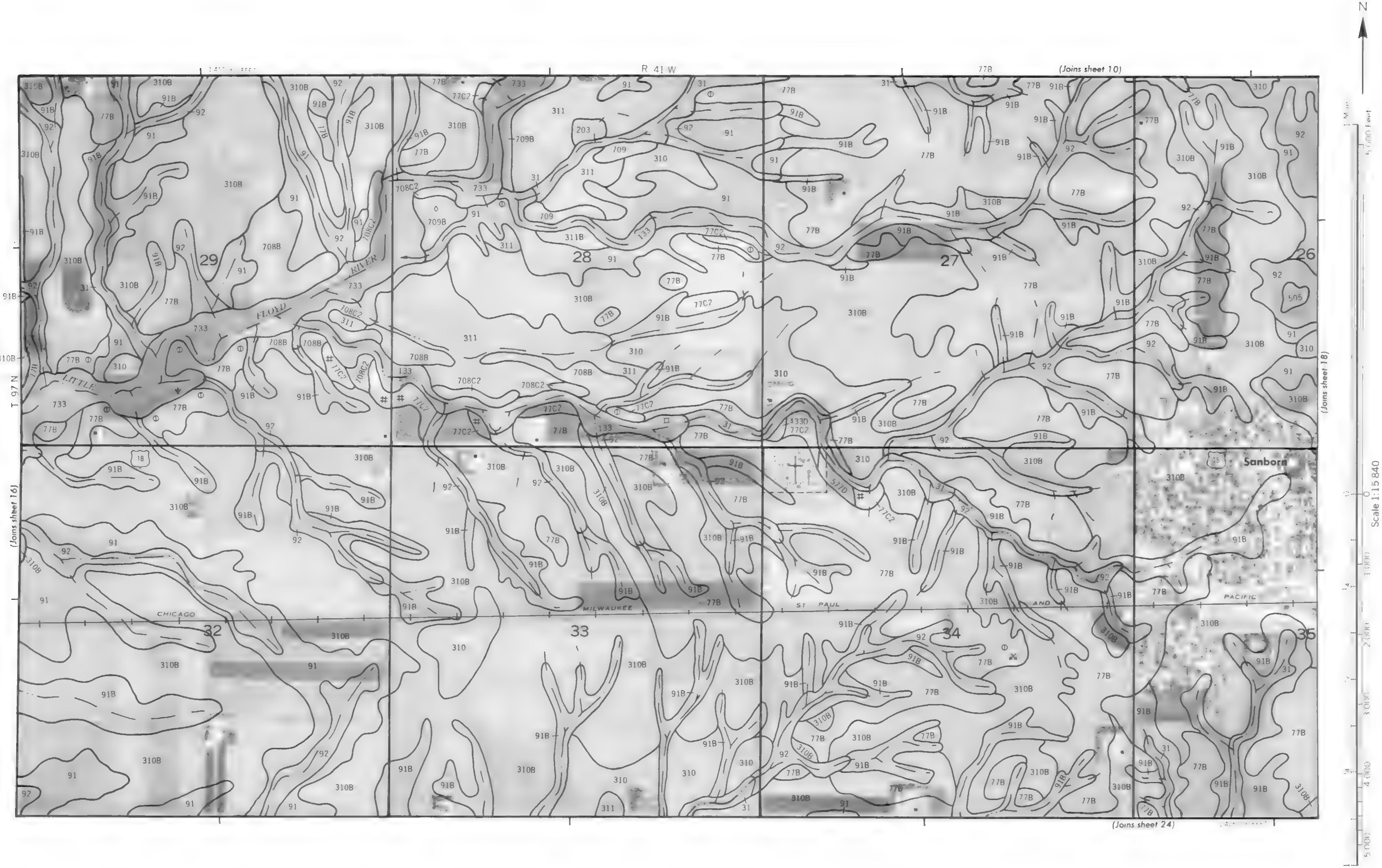

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 5)
R. 40 W.
(Joins sheet 11)
(Joins sheet 13)
(Joins sheet 19)
T. 97 N.
16
15
14
13
21
22
23
24
Creek
CHICAGO
ROCK ISLAND
AND
PACIFIC

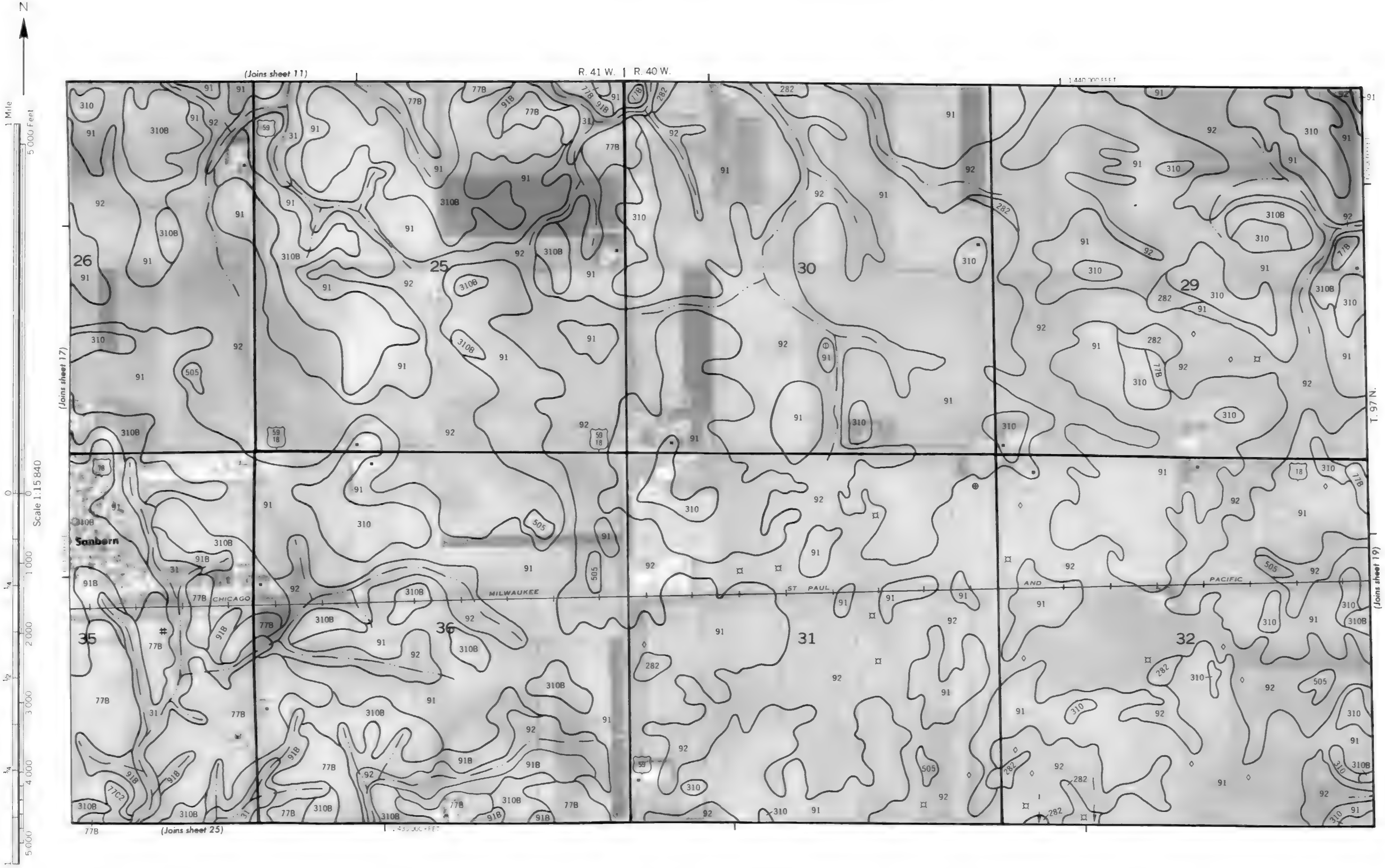

13
N
R 40 W
R 39 W
T 97 N
(Joins sheet 6)
(Joins sheet 14)
(Joins sheet 20)
(Joins sheet 12)
Waterman Creek
13
18
17
16
24
19
20
21
Scale 1:15 840

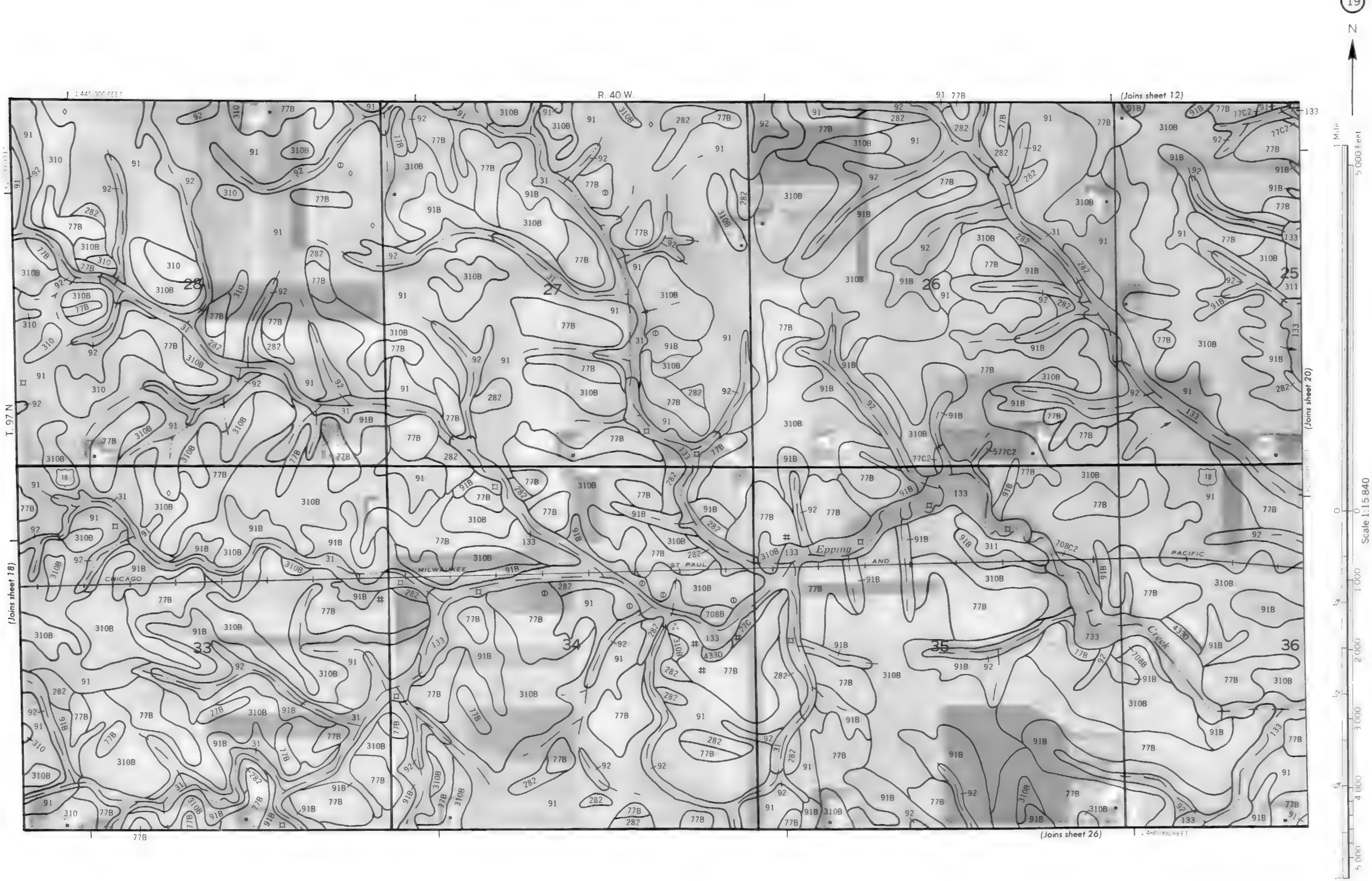

N
(Joins sheet 7)
R. 39 W.
(Joins sheet 13)
(Joins sheet 21)
T. 97 N.
CLAY COUNTY
Scale 1:15 840
1 Mile
5 000 Feet
15
14
13
22
23
24

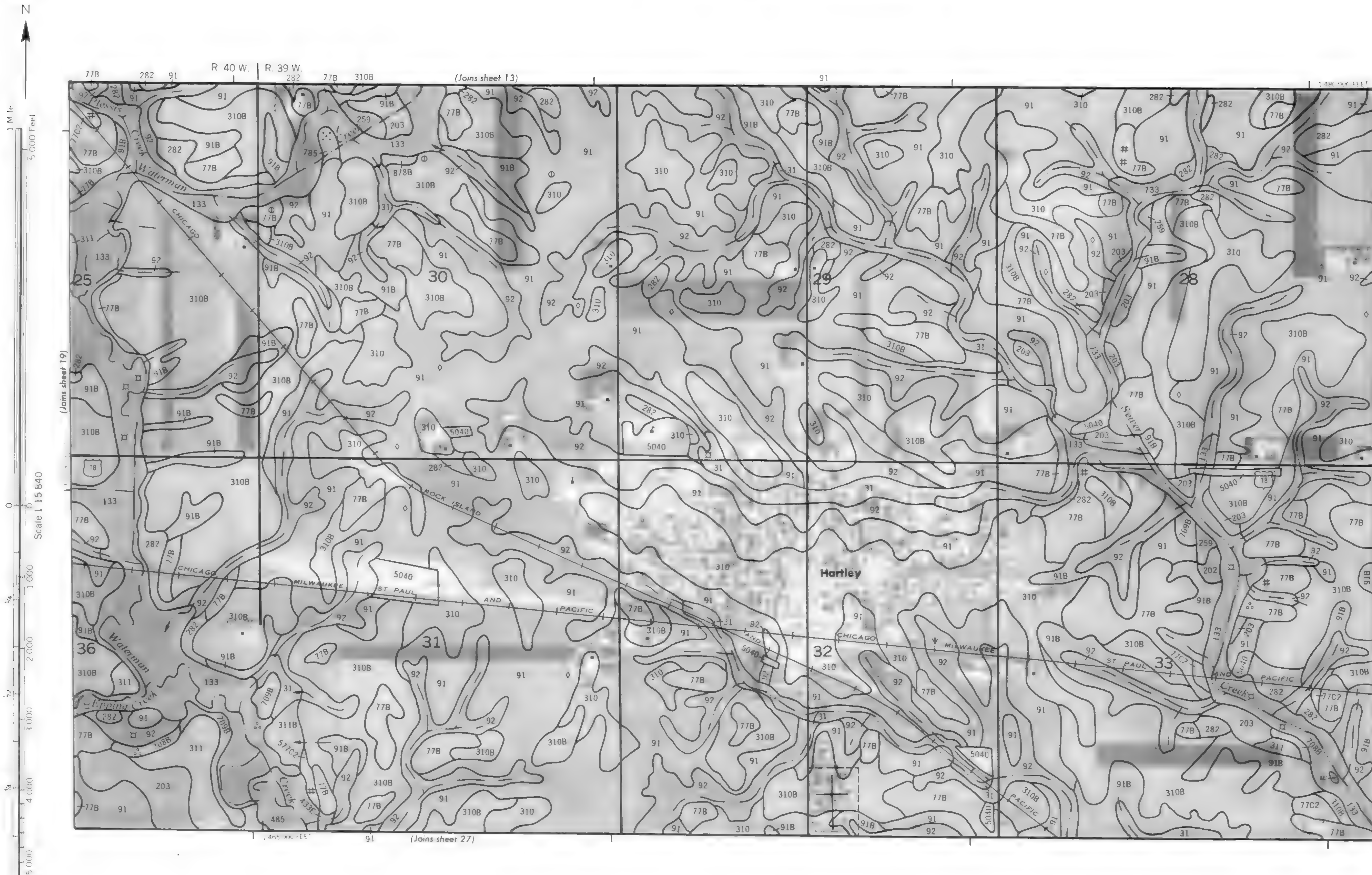

15
N
R 42 W.
(Joins sheet 8)
(Joins sheet 16)
(Joins sheet 22)
T 97 N
SIOUX COUNTY
SHELDON
Wolf Creek
FLOYD RIVER
HILLS PARK
CHICAGO AND NORTH WESTERN
ILLINOIS CENTRAL AND GULF
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
30
29
28
27
31
32
33
34
Scale 1:15 840
1 Mile
5 000 Feet


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 9)
(Joins sheet 15)
(Joins sheet 17)
(Joins sheet 23)
R. 42 W.
R. 41 W.
T. 97 N.
27
26
25
30
34
35
36
31
CHICAGO
MILWAUKEE
ST
PAUL
AND
PACIFIC
Sweeney
Creek
FLOYD
RIVER
LITTLE

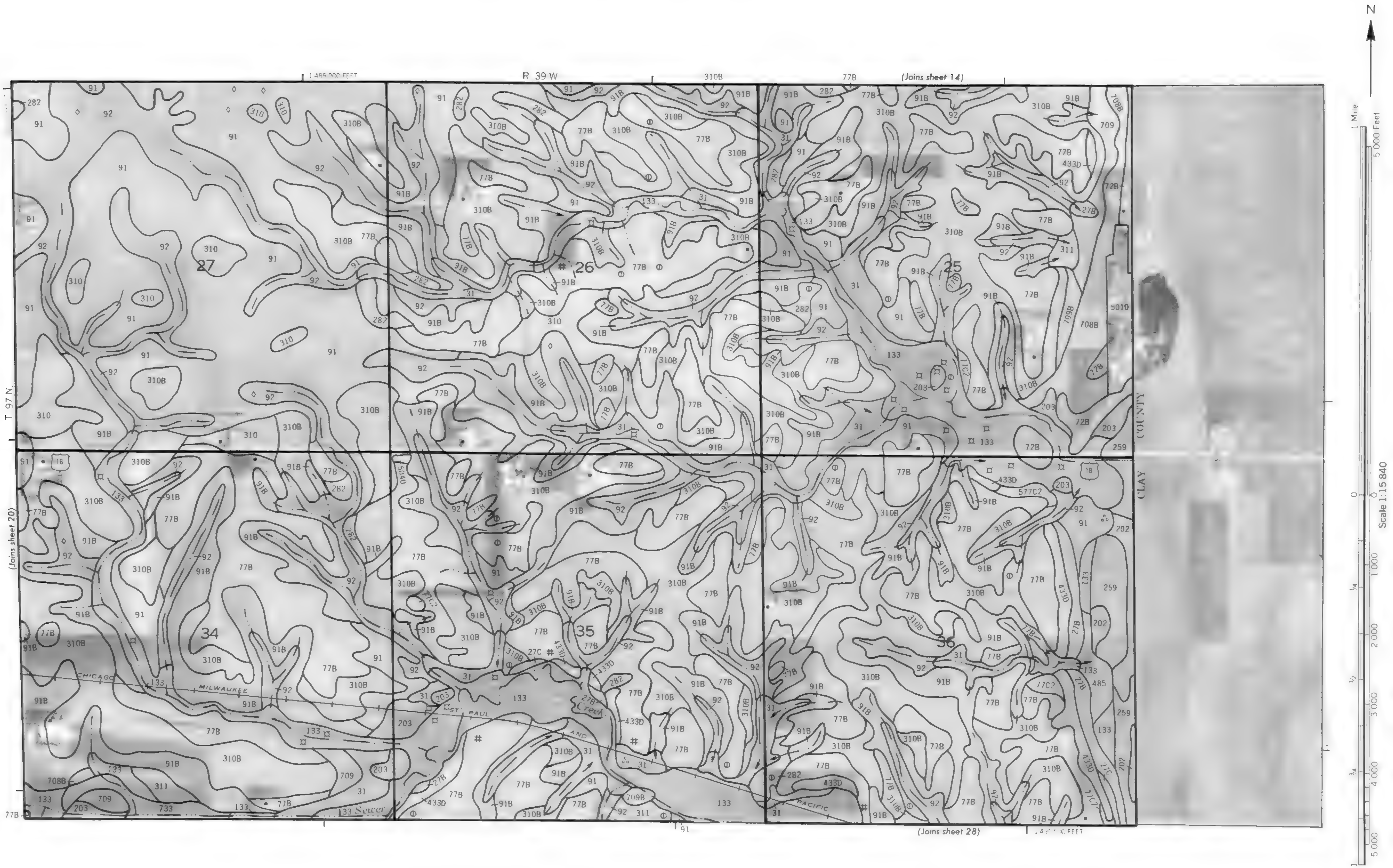

N
R 41 W
(Joins sheet 10)
(Joins sheet 16)
(Joins sheet 18)
(Joins sheet 24)
T 97 N
29
28
27
26
32
33
34
35
FLOYD
RIVER
LITTLE
CHICAGO
MILWAUKEE
ST PAUL
AND
PACIFIC
Sanborn
18
Scale 1:15 840
1 Mile
5 000 Feet
0
1 000
2 000
3 000
4 000
5 000

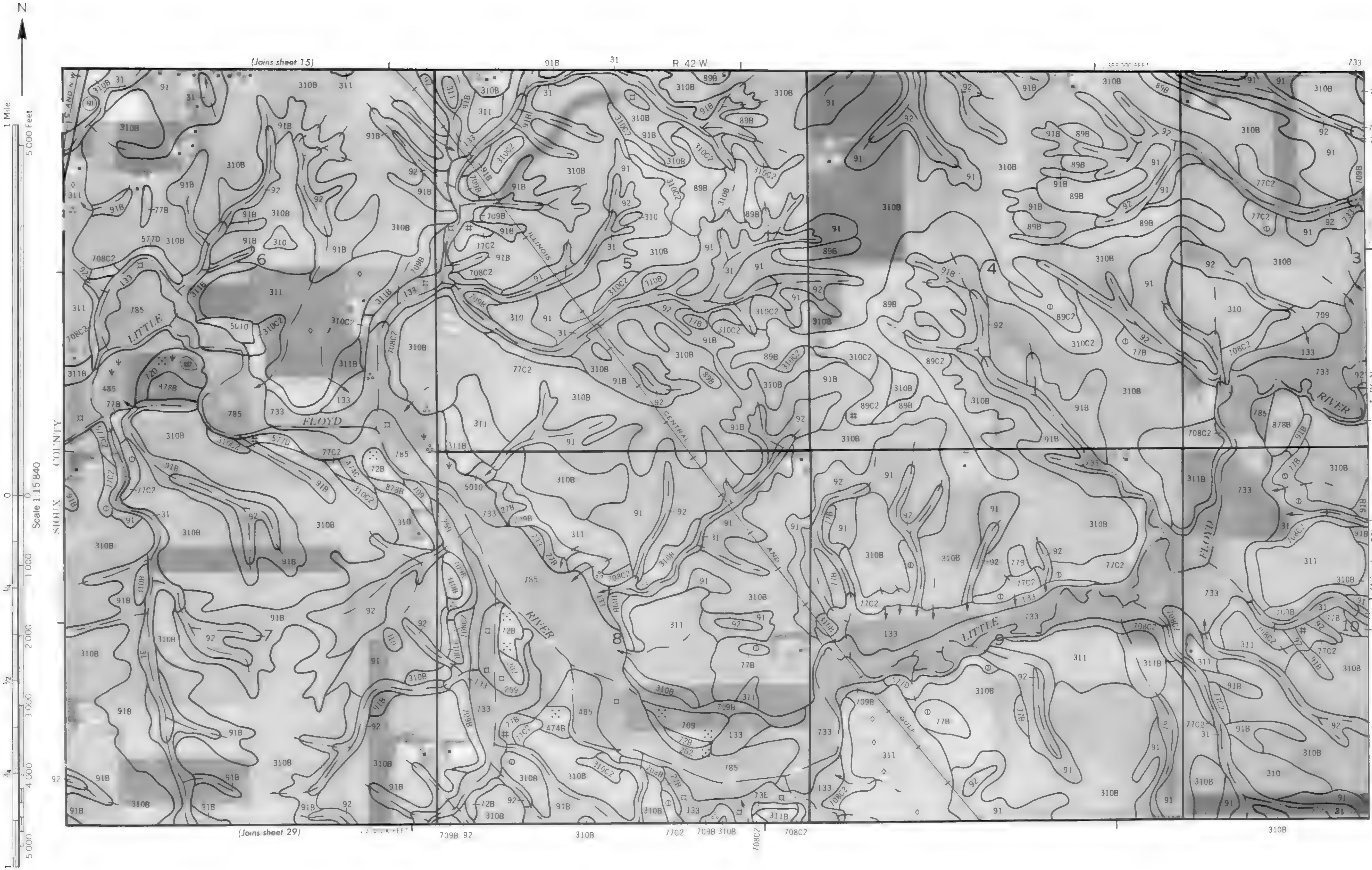

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 11)
R. 41 W.
R. 40 W.
(Joins sheet 17)
(Joins sheet 19)
(Joins sheet 25)
T. 97 N.
Sanborn
CHICAGO
MILWAUKEE
ST PAUL
AND
PACIFIC
26
25
30
29
35
36
31
32

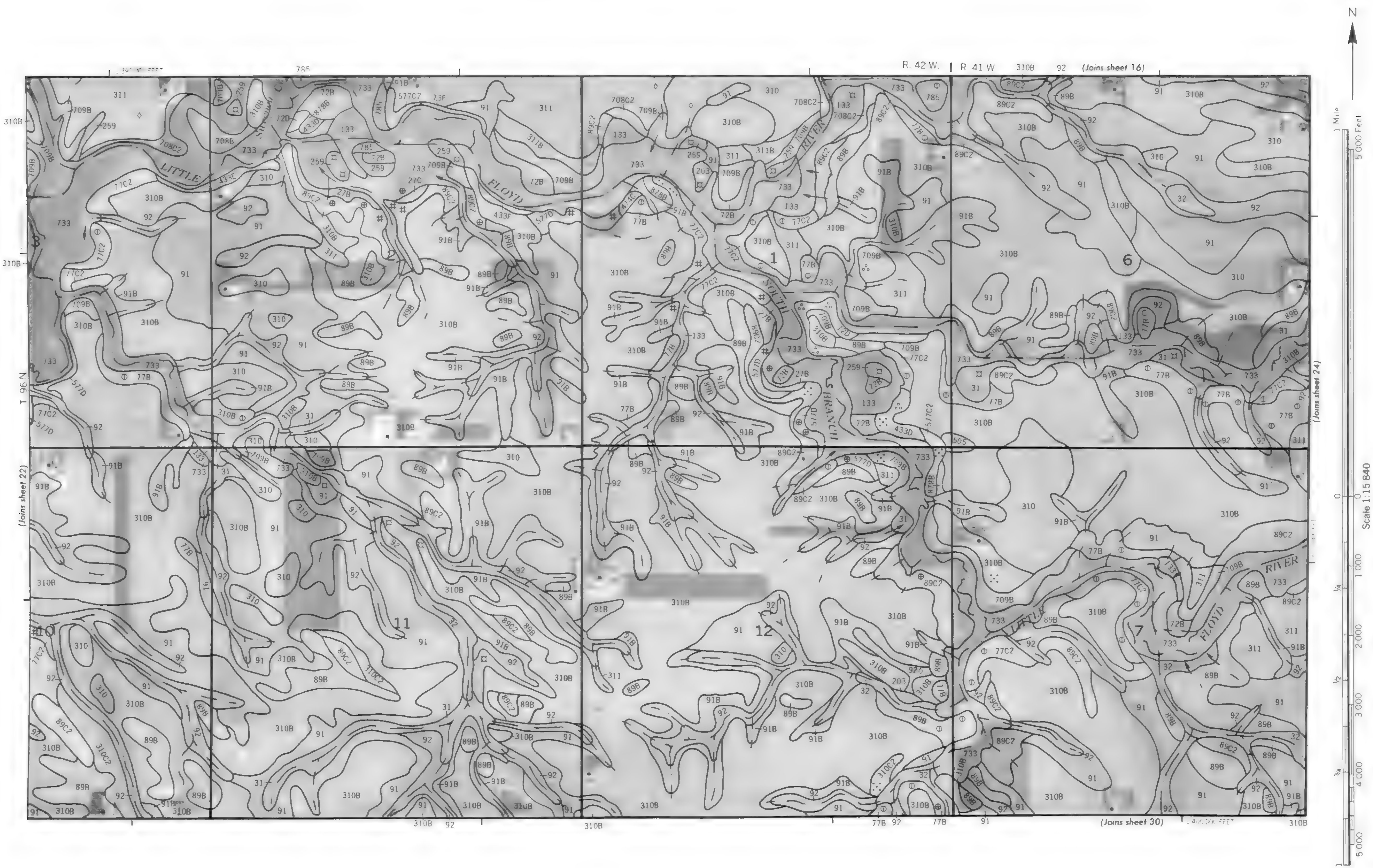

19
N
R. 40 W.
T. 97 N.
(Joins sheet 12)
(Joins sheet 20)
(Joins sheet 26)
(Joins sheet 18)
28
27
26
25
33
34
35
36
Epping
Creek
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
18
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000

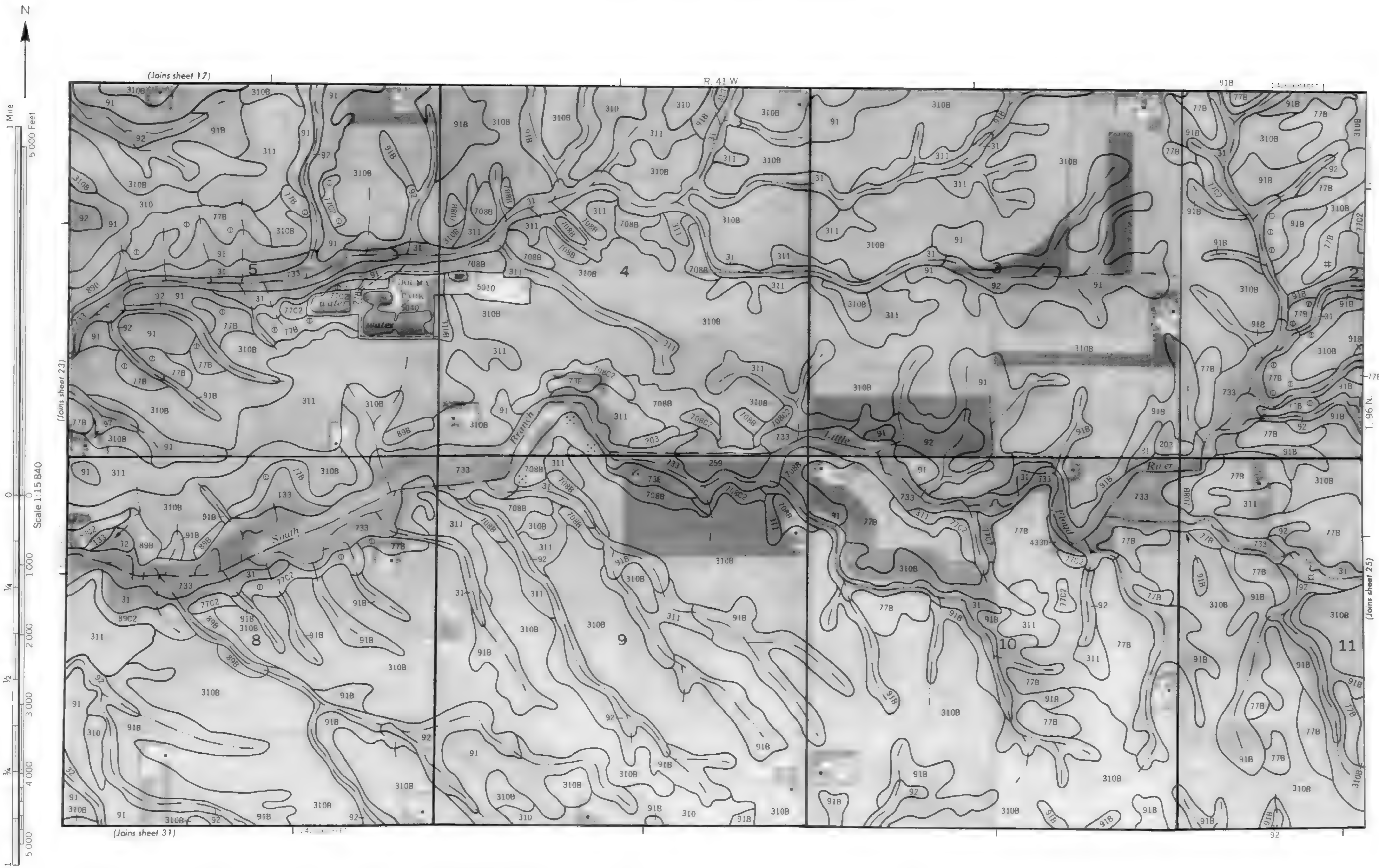

N
R. 40 W.
R. 39 W.
(Joins sheet 13)
(Joins sheet 19)
(Joins sheet 21)
(Joins sheet 27)
T. 97 N.
Hartley
Waterman Creek
Plessis Creek
Epping Creek
Sanger Creek
CHICAGO ROCK ISLAND
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
25
30
29
28
36
31
32
33
1 Mile
5 000 Feet
Scale 1:15 840

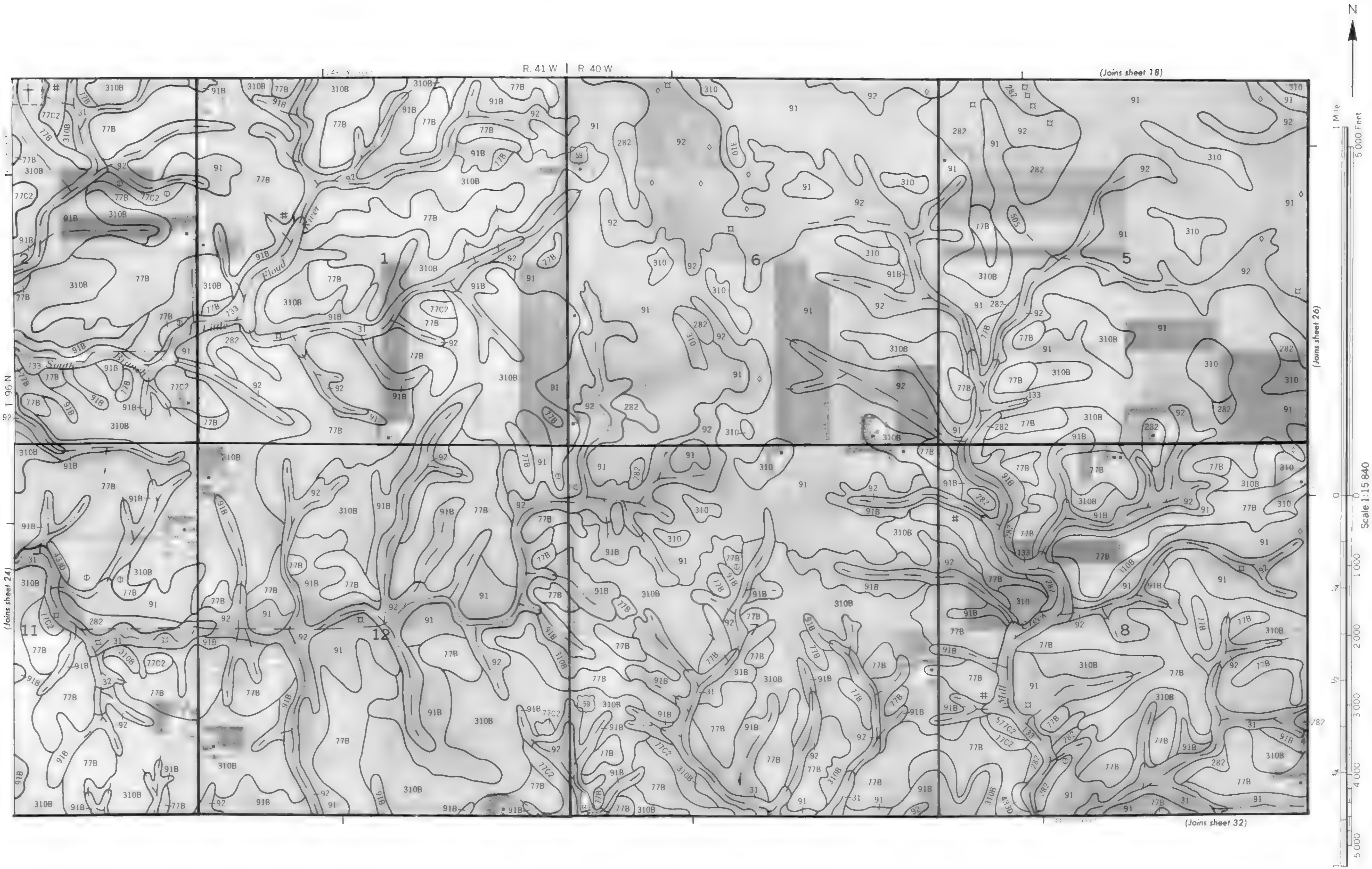
21

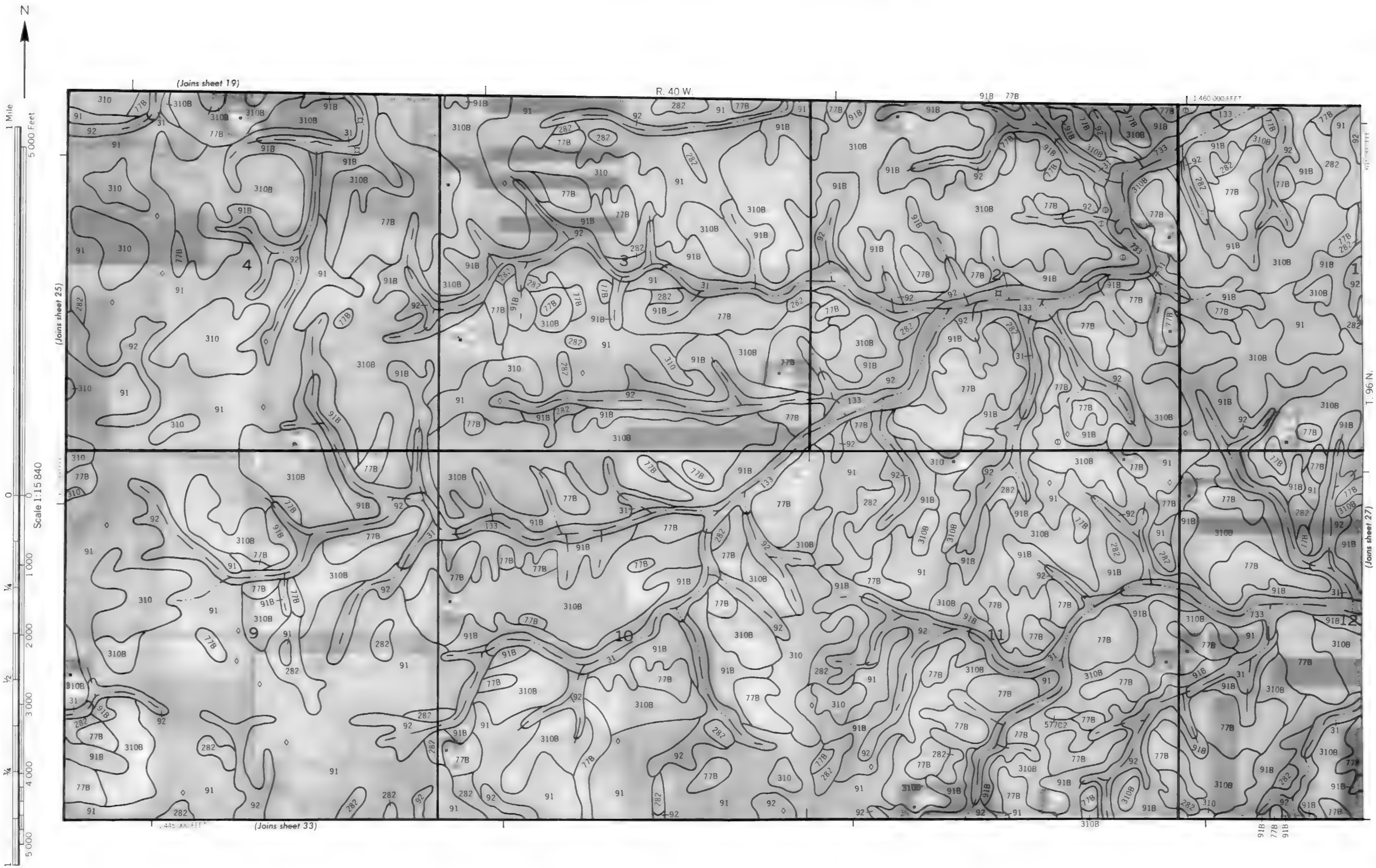

N
R 39 W
T 97 N
(Joins sheet 14)
(Joins sheet 20)
(Joins sheet 28)
CLAY COUNTY
27
26
25
34
35
36
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
Creek
Sewer
18
1 Mile
5 000 Feet
Scale 1:15 840
0
1000
2000
3000
4000
5000
¼
½
¾

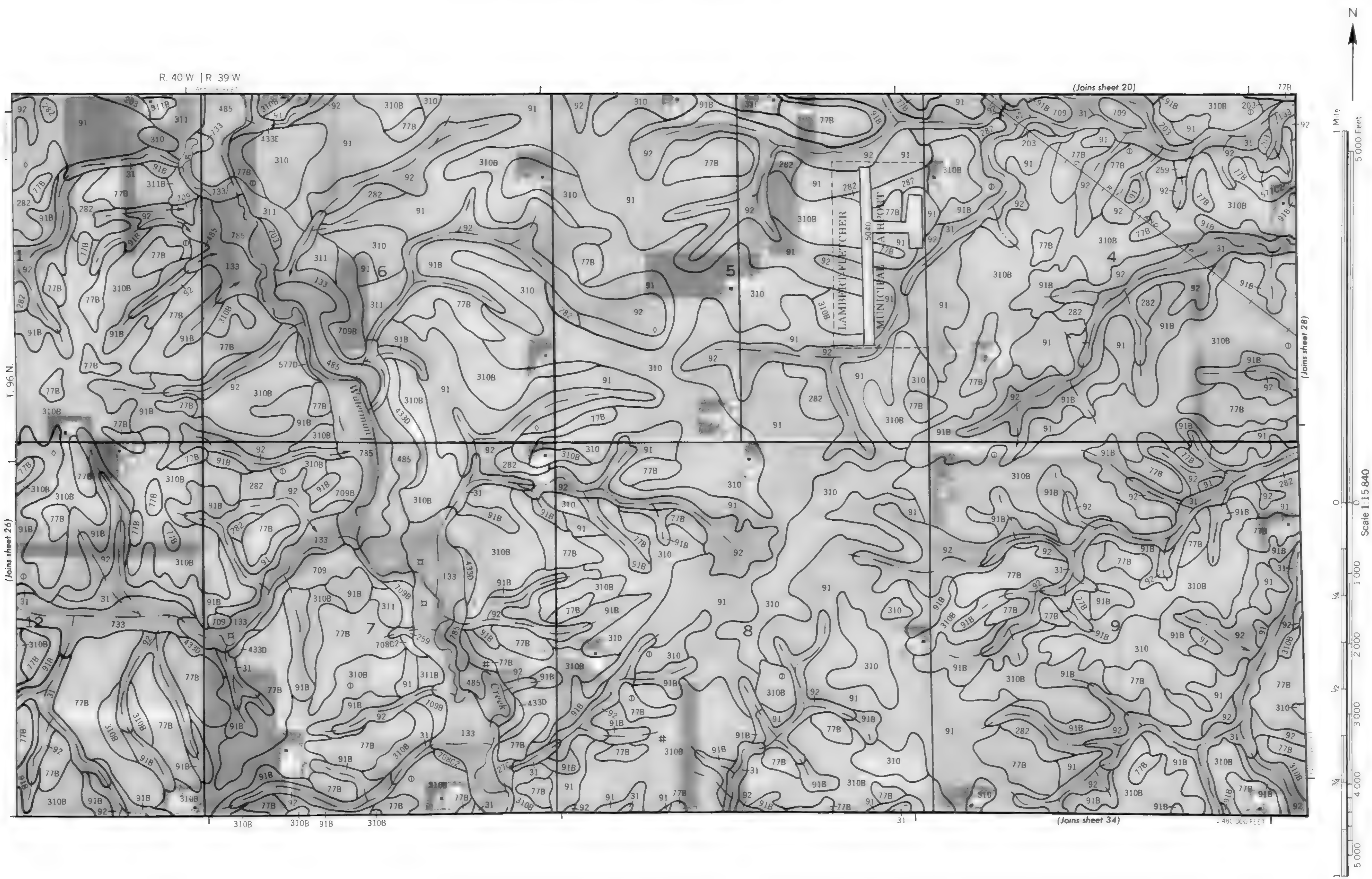

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 15)
R. 42 W.
T. 96 N.
(Joins sheet 23)
(Joins sheet 29)
SIOUX COUNTY
LITTLE FLOYD RIVER
ILLINOIS CENTRAL AND GULF
3
4
5
6
7
8
9
10


N
R. 42 W.
R. 41 W
(Joins sheet 16)
(Joins sheet 24)
(Joins sheet 30)
(Joins sheet 22)
T. 96 N.
LITTLE
FLOYD
RIVER
SOUTH
BRANCH
1
2
3
6
7
10
11
12
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 17)
R. 41 W.
(Joins sheet 23)
(Joins sheet 25)
(Joins sheet 31)
T. 96 N.
5
4
3
2
8
9
10
11
South
Branch
Little
River
Water

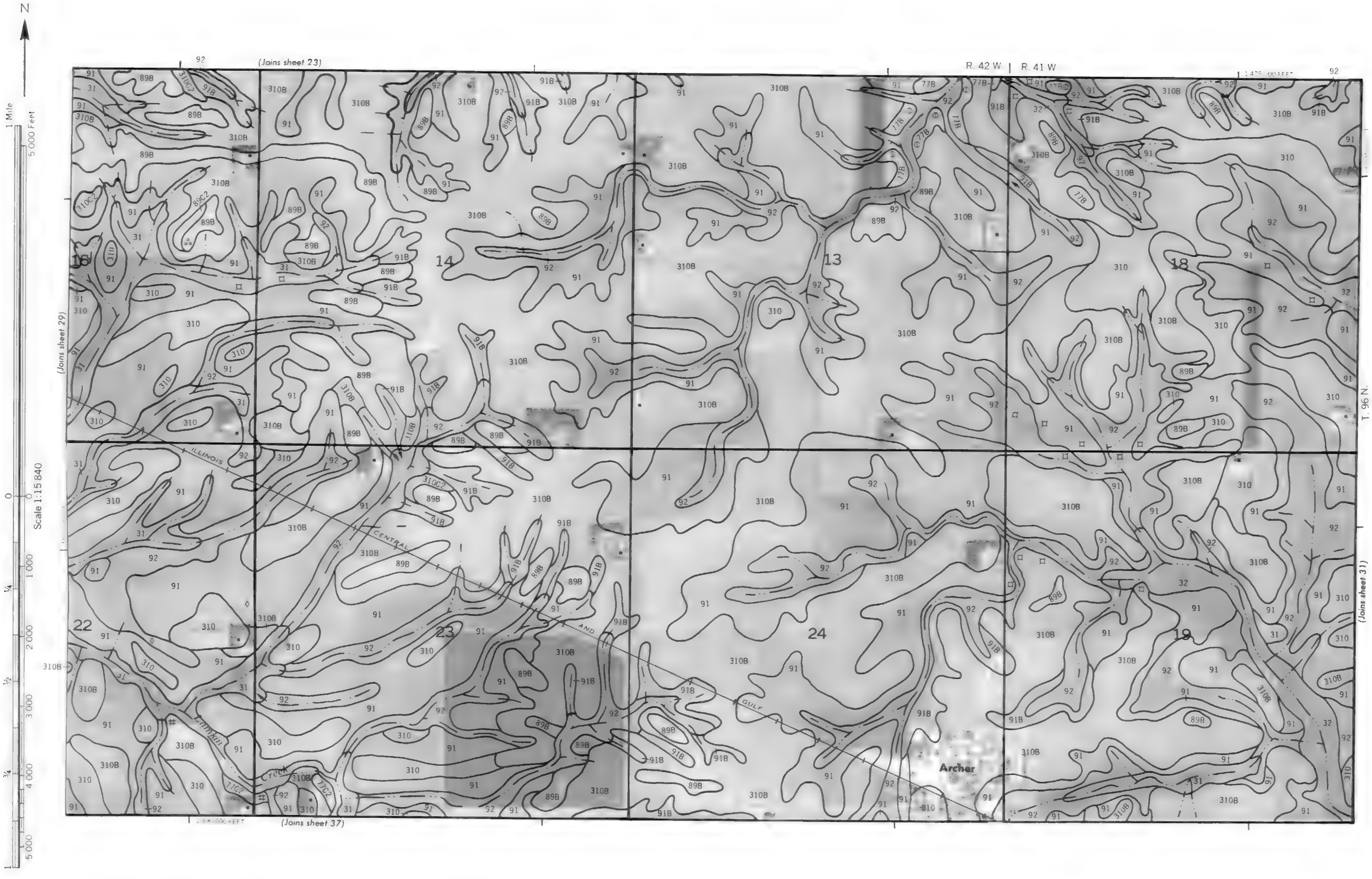

N
R. 41 W
R. 40 W
(Joins sheet 18)
(Joins sheet 26)
(Joins sheet 32)
(Joins sheet 24)
T 96 N
Floyd River
Little South Branch
Mill Creek
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
1
2
5
6
7
8
11
12

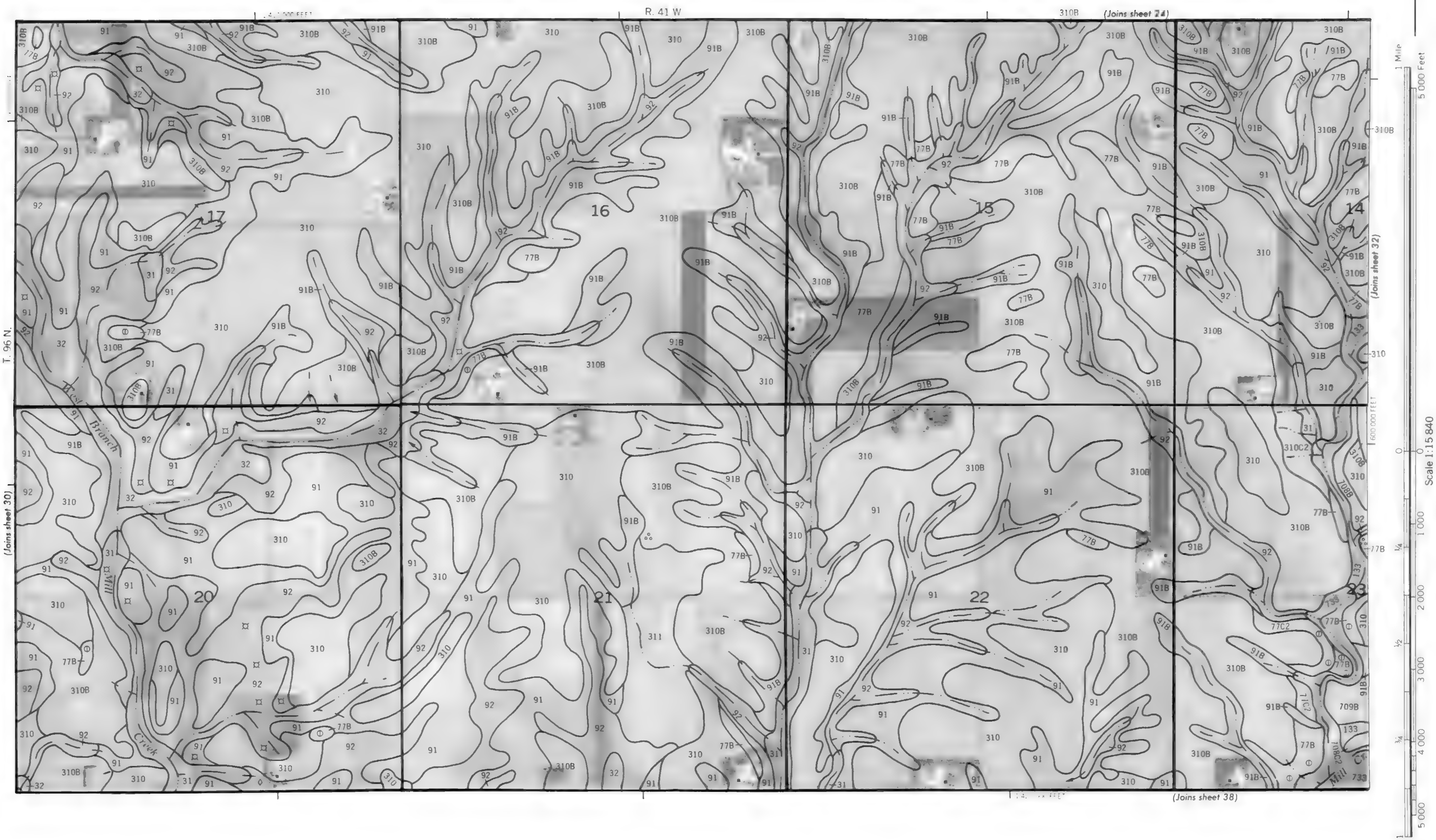

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 19)
R. 40 W.
1 460 000 FEET
(Joins sheet 25)
(Joins sheet 27)
T. 96 N.
(Joins sheet 33)
4
3
2
1
9
10
11
12

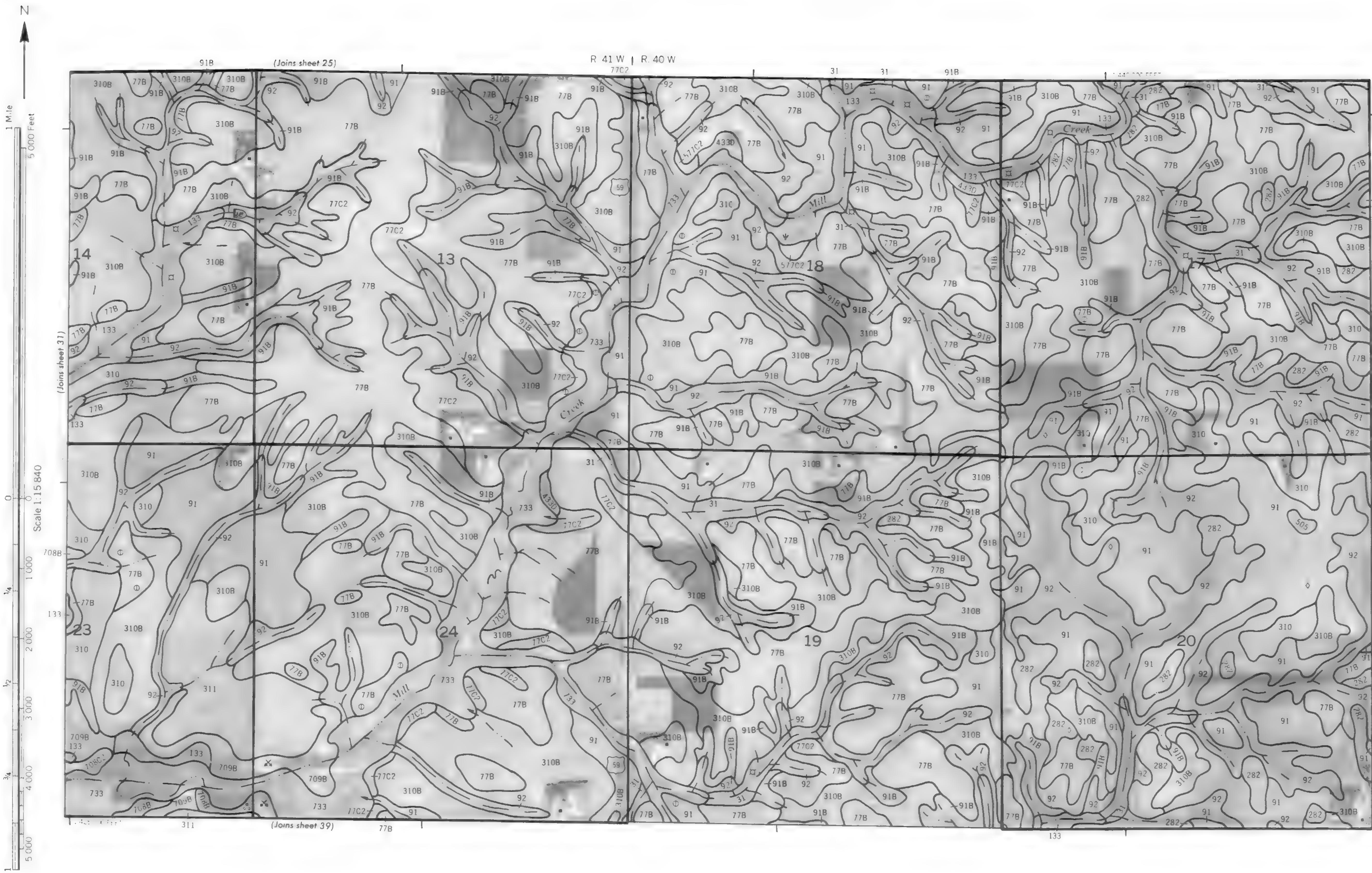

N
R. 40 W | R. 39 W
T. 96 N.
(Joins sheet 20)
(Joins sheet 28)
(Joins sheet 34)
(Joins sheet 26)
LAMBERT FLETCHER
MUNICIPAL AIRPORT
5040
Waterman
Creek
1
4
5
6
7
8
9
12
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000

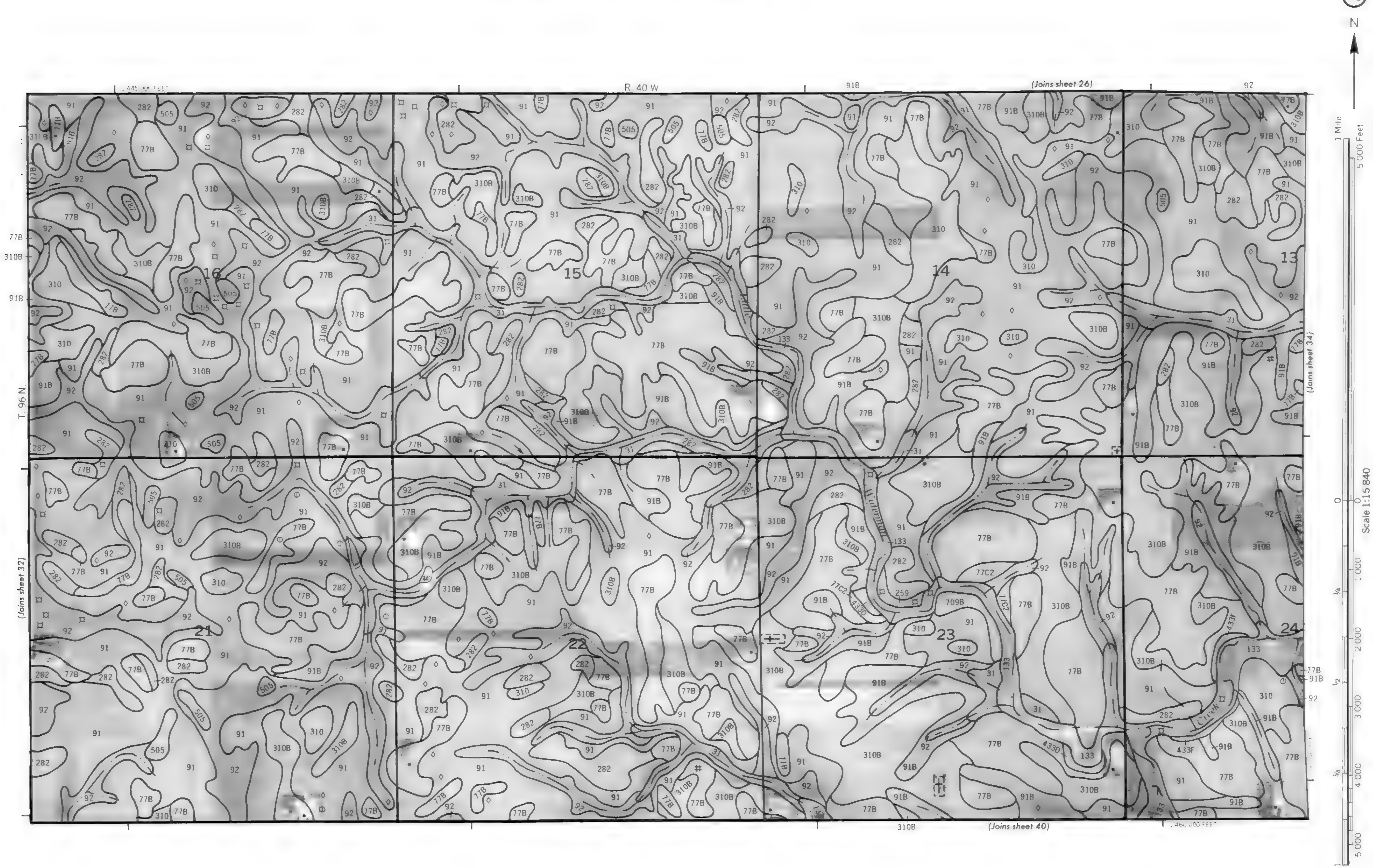

28
N
(Joins sheet 21)
R. 39 W.
(Joins sheet 27)
(Joins sheet 35)
T. 96 N.
CLAY COUNTY
Scale 1:15 840
1 Mile
5 000 Feet
Sewer Creek
CHICAGO ROCK ISLAND AND PACIFIC
C. M. ST. P. AND P.

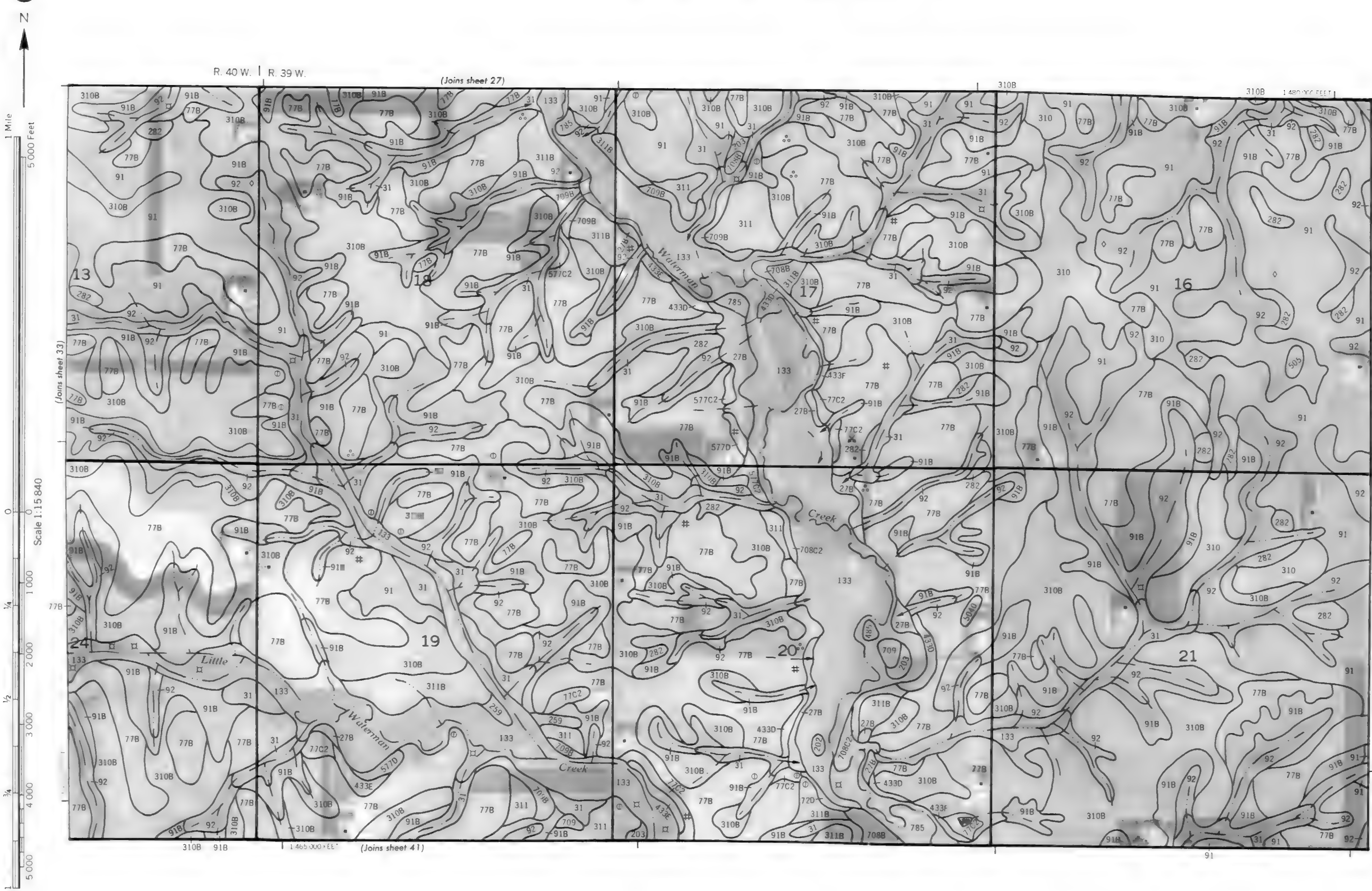

29
N
R 42 W
(Joins sheet 22)
(Joins sheet 30)
(Joins sheet 36)
T. 96 N
SIOUX COUNTY
18
17
16
15
19
20
21
22
ILLINOIS CENTRAL AND GULF
Lumkin Creek
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000

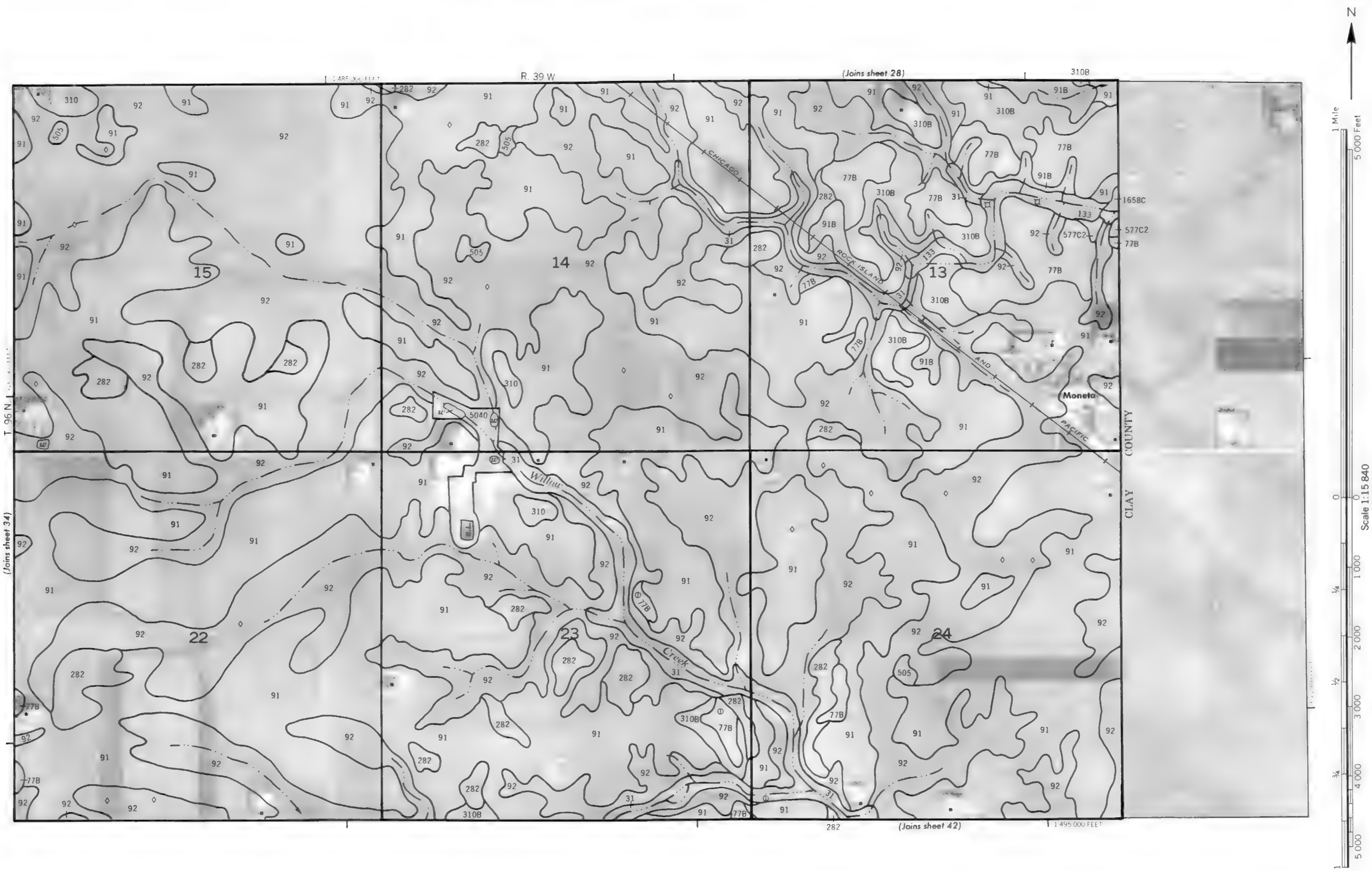

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 23)
(Joins sheet 29)
(Joins sheet 31)
(Joins sheet 37)
R. 42 W
R. 41 W
T. 96 N.
14
13
18
23
24
19
22
ILLINOIS
CENTRAL
AND
GULF
Archer
Lamkin
Creek

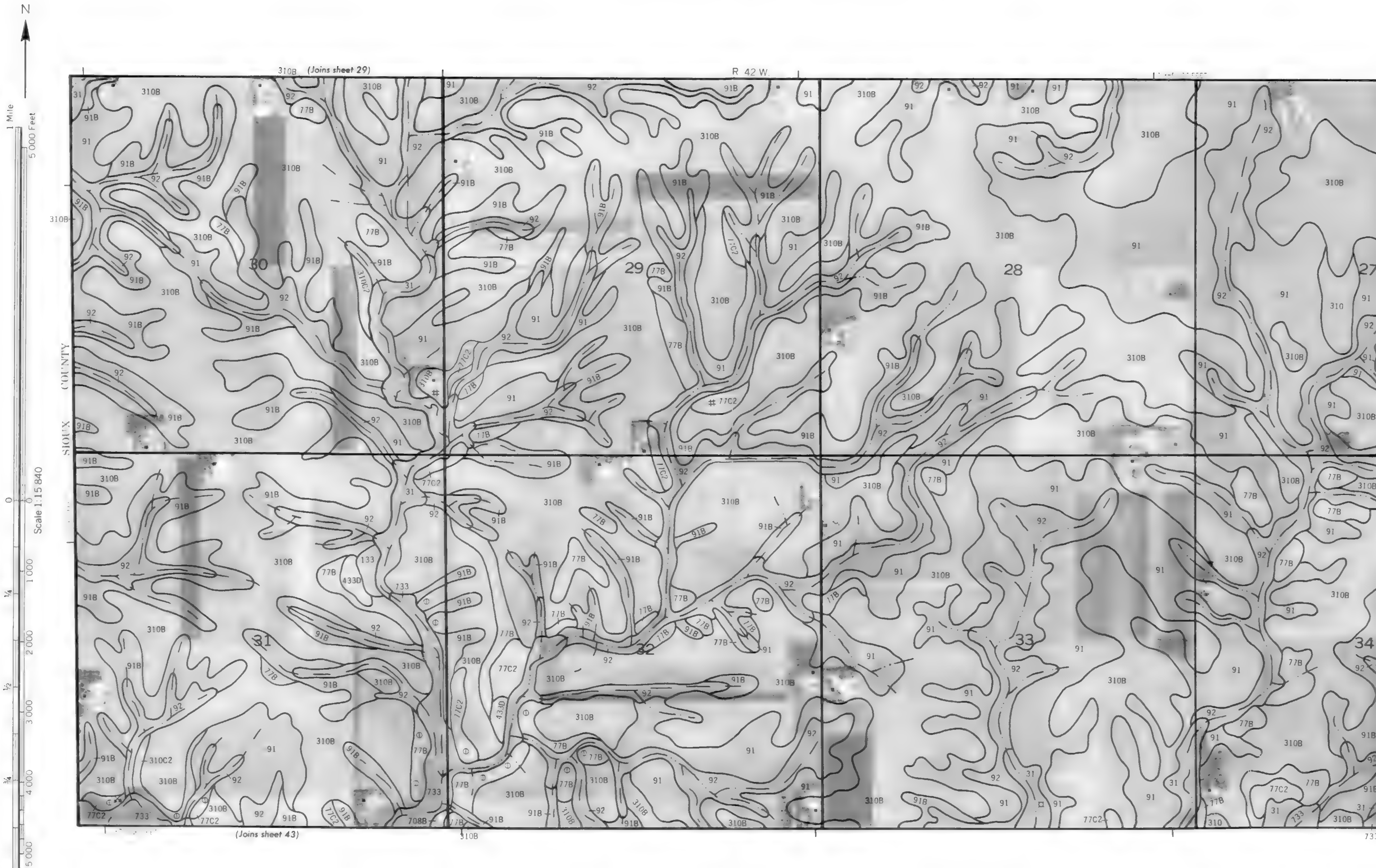

N
R. 41 W
T. 96 N.
(Joins sheet 24)
(Joins sheet 32)
(Joins sheet 30)
(Joins sheet 38)
17
16
15
14
20
21
22
23
West Branch
Mill Creek
Mill Cr.
Scale 1:15 840
1 Mile
5 000 Feet
0
1 000
2 000
3 000
4 000
5 000
¼
½
¾


32
N
1 Mile
5 000 Feet
Scale 1:15 840
R 41 W | R 40 W
(Joins sheet 25)
(Joins sheet 31)
(Joins sheet 33)
(Joins sheet 39)
T 96 N.
13
14
17
18
19
20
23
24
Mill
Creek
59

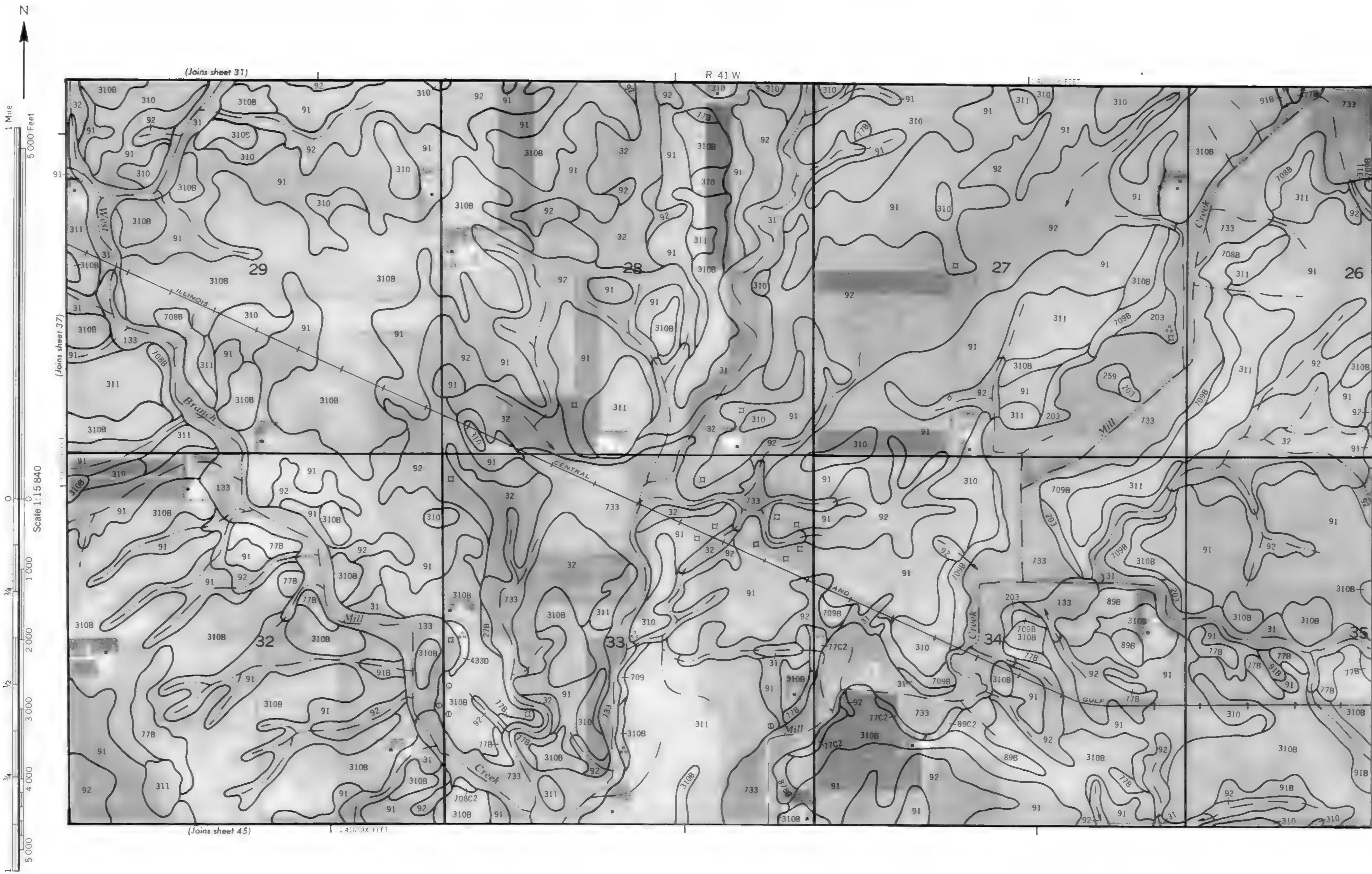

33
N
(Joins sheet 26)
(Joins sheet 32)
(Joins sheet 34)
(Joins sheet 40)
R. 40 W
T. 96 N.
16
15
14
13
21
22
23
24
Creek
1 Mile
5 000 Feet
Scale 1:15 840

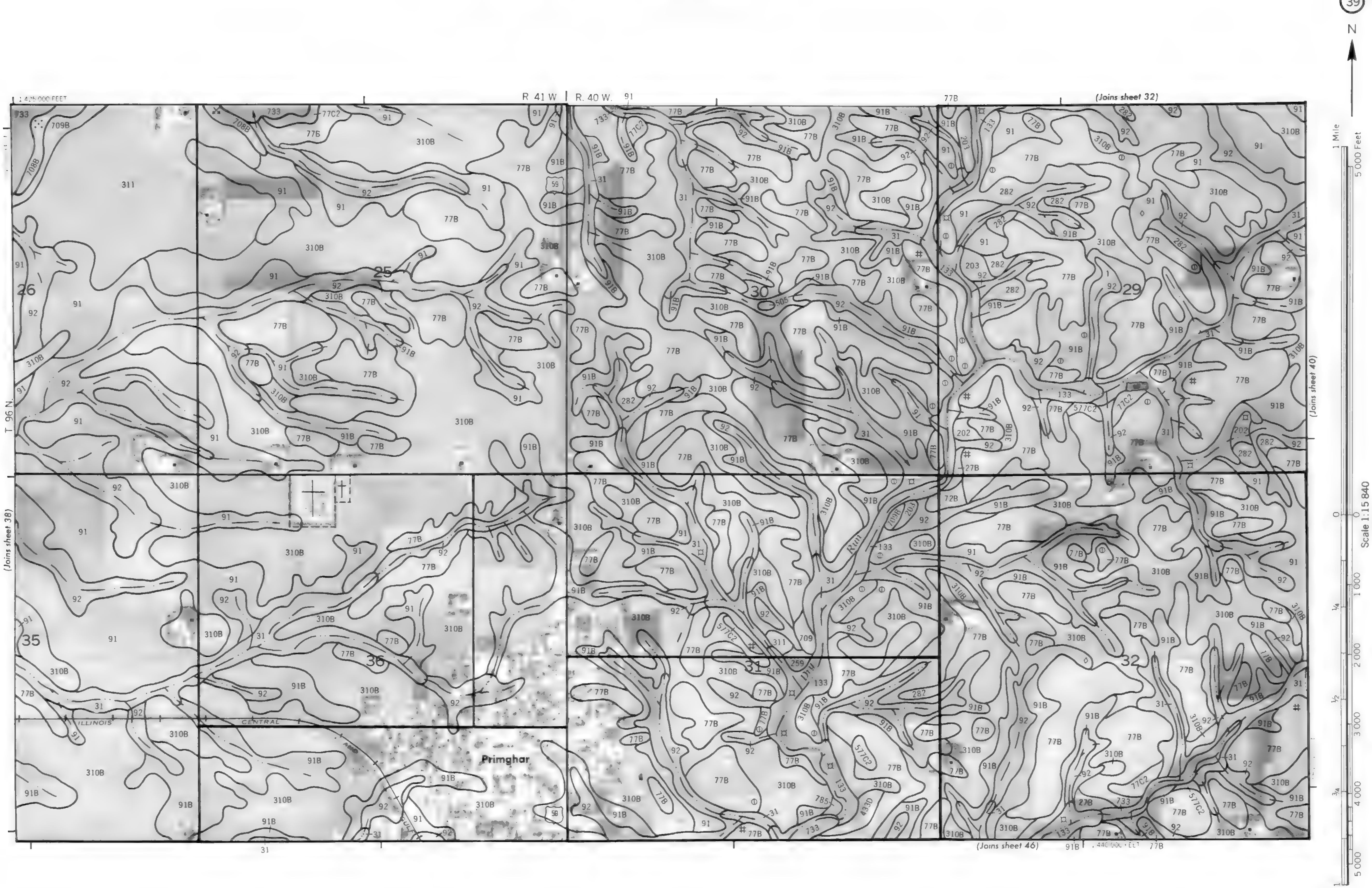

N
R. 40 W.
R. 39 W.
(Joins sheet 27)
(Joins sheet 33)
(Joins sheet 35)
(Joins sheet 41)
T. 96 N.
1 480 000 FEET
1 465 000 FEET
13
18
17
16
24
19
20
21
Waterman
Creek
Little
Waterman
Creek
Creek
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
¼
½
¾
1


35
N
(Joins sheet 28)
R. 39 W
T. 96 N.
(Joins sheet 34)
(Joins sheet 42)
1 495 000 FEET
CLAY COUNTY
Moneta
CHICAGO ROCK ISLAND AND PACIFIC
Willow Creek
15
14
13
22
23
24
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000

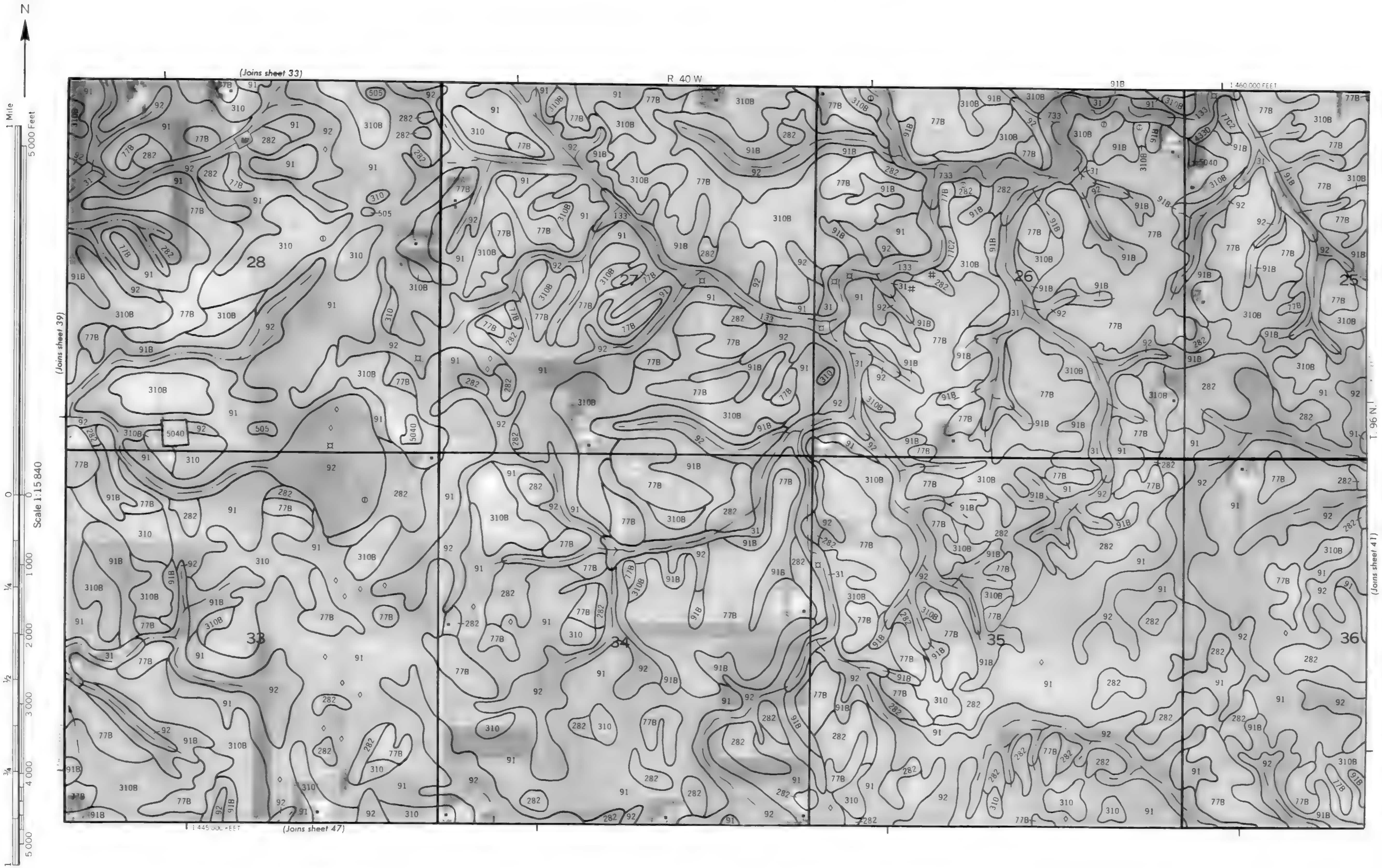

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 29)
R. 42 W.
T. 96 N.
(Joins sheet 37)
(Joins sheet 43)
SIOUX COUNTY
30
29
28
27
31
32
33
34

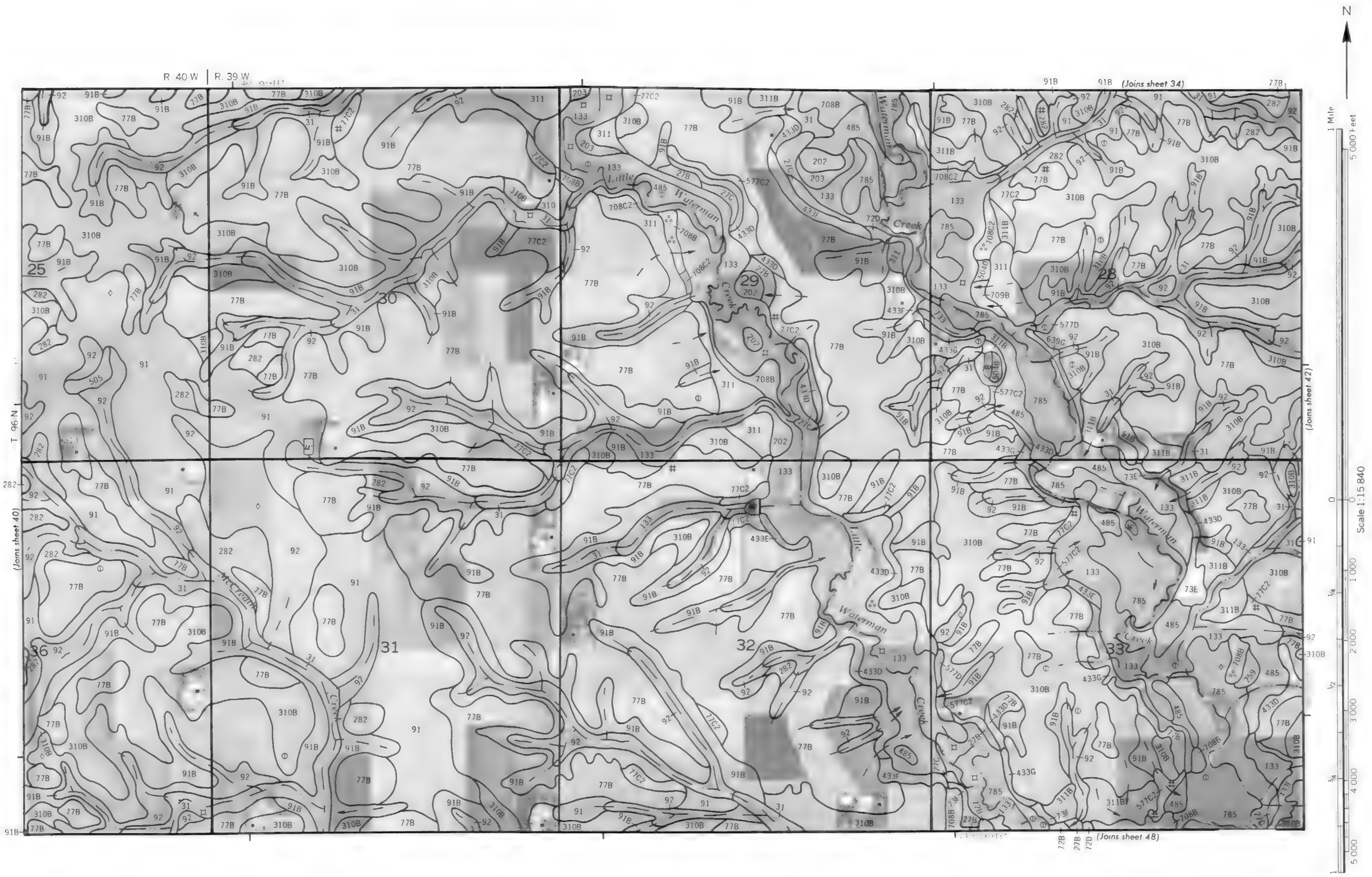

37
N
R. 42 W.
R. 41 W.
(Joins sheet 30)
(Joins sheet 38)
(Joins sheet 44)
(Joins sheet 36)
T. 96 N.
ILLINOIS
CENTRAL
AND
GULF
Creek
25
26
27
30
31
34
35
36
1 Mile
5 000 Feet
Scale 1:15 840
1 000
2 000
3 000
4 000
5 000
0
¼
½
¾
1

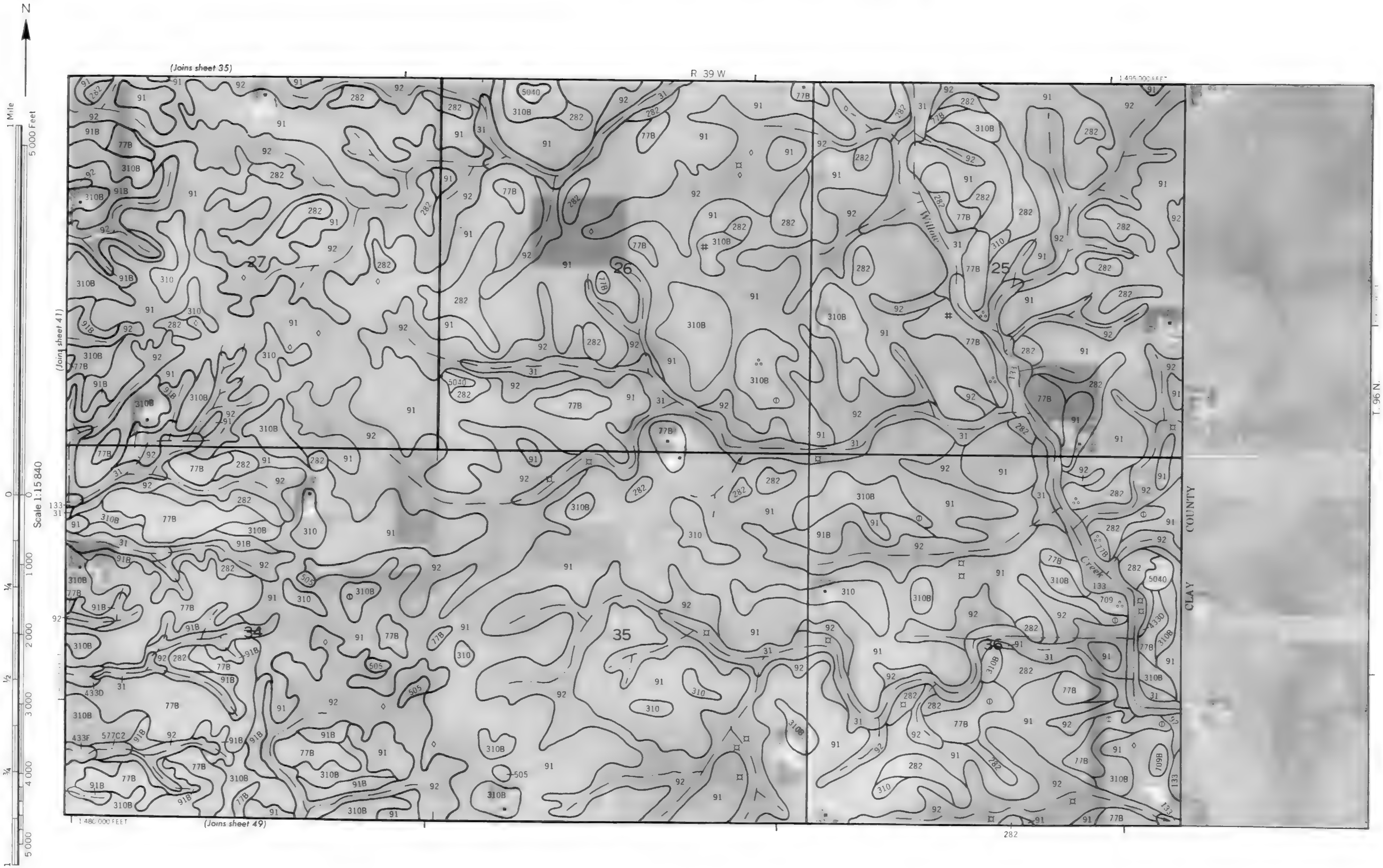

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 31)
R 41 W
(Joins sheet 37)
(Joins sheet 39)
(Joins sheet 45)
T. 96 N.
29
28
27
26
32
33
34
35
West Branch
Mill Creek
ILLINOIS CENTRAL GULF

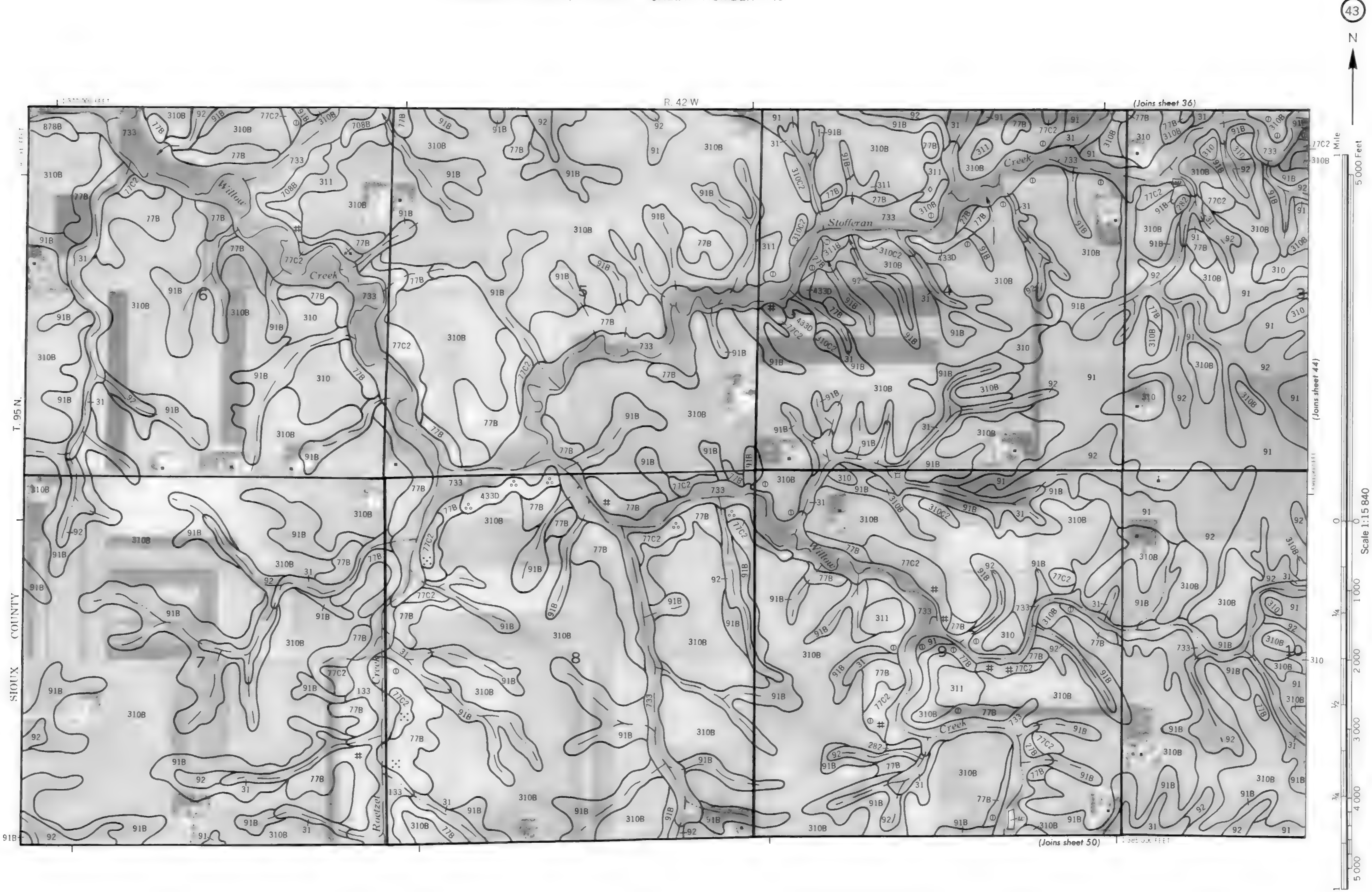


39
N
(Joins sheet 32)
(Joins sheet 40)
(Joins sheet 46)
(Joins sheet 38)
R. 41 W.
R. 40 W.
T. 96 N.
25
26
29
30
31
32
35
36
Primghar
ILLINOIS
CENTRAL
Run
59
Scale 1:15 840
1 Mile
5 000 Feet

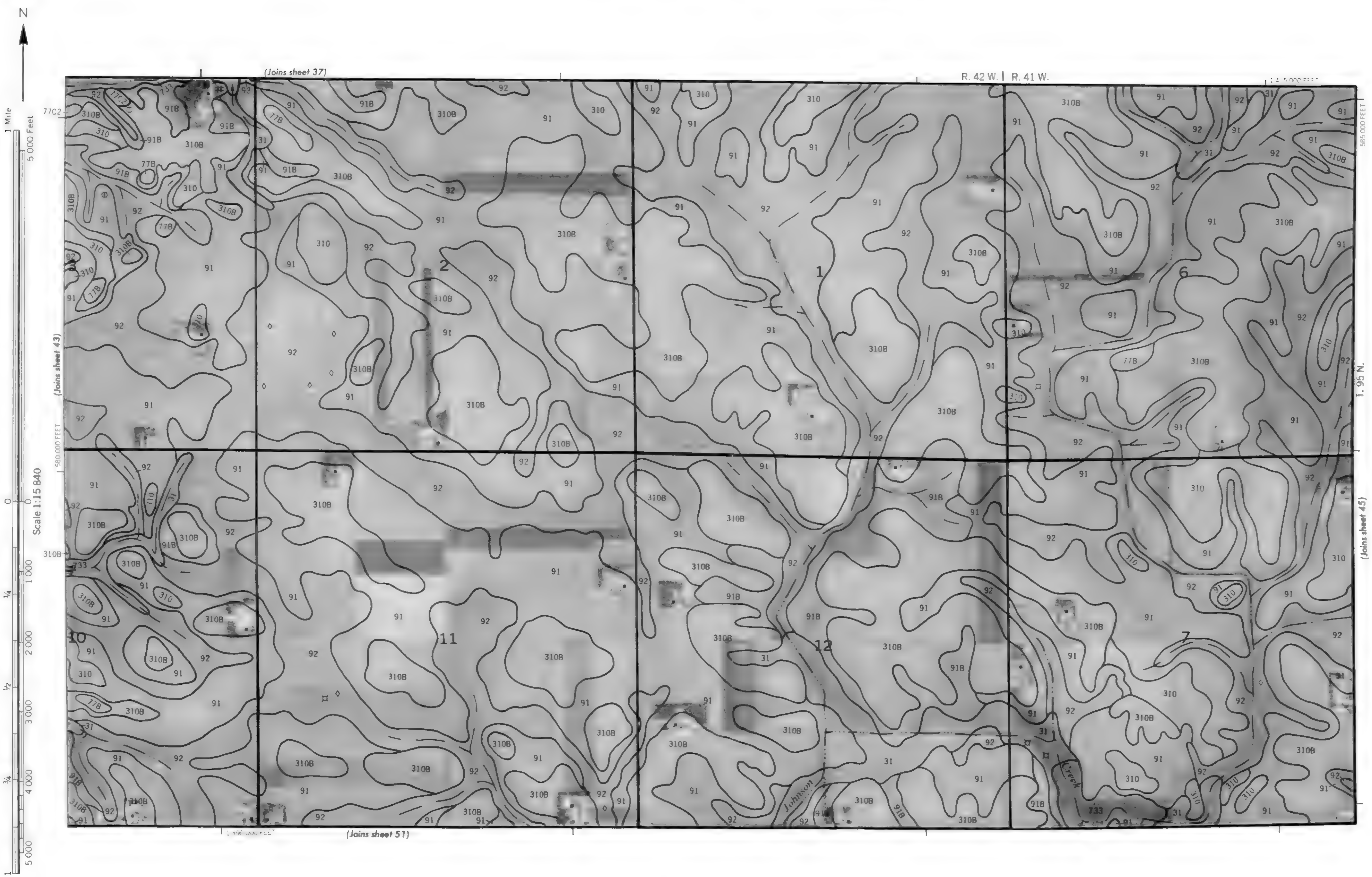

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 33)
R. 40 W.
1 460 000 FEET
(Joins sheet 39)
(Joins sheet 41)
T. 96 N.
1 445 000 FEET
(Joins sheet 47)
28
27
26
25
33
34
35
36

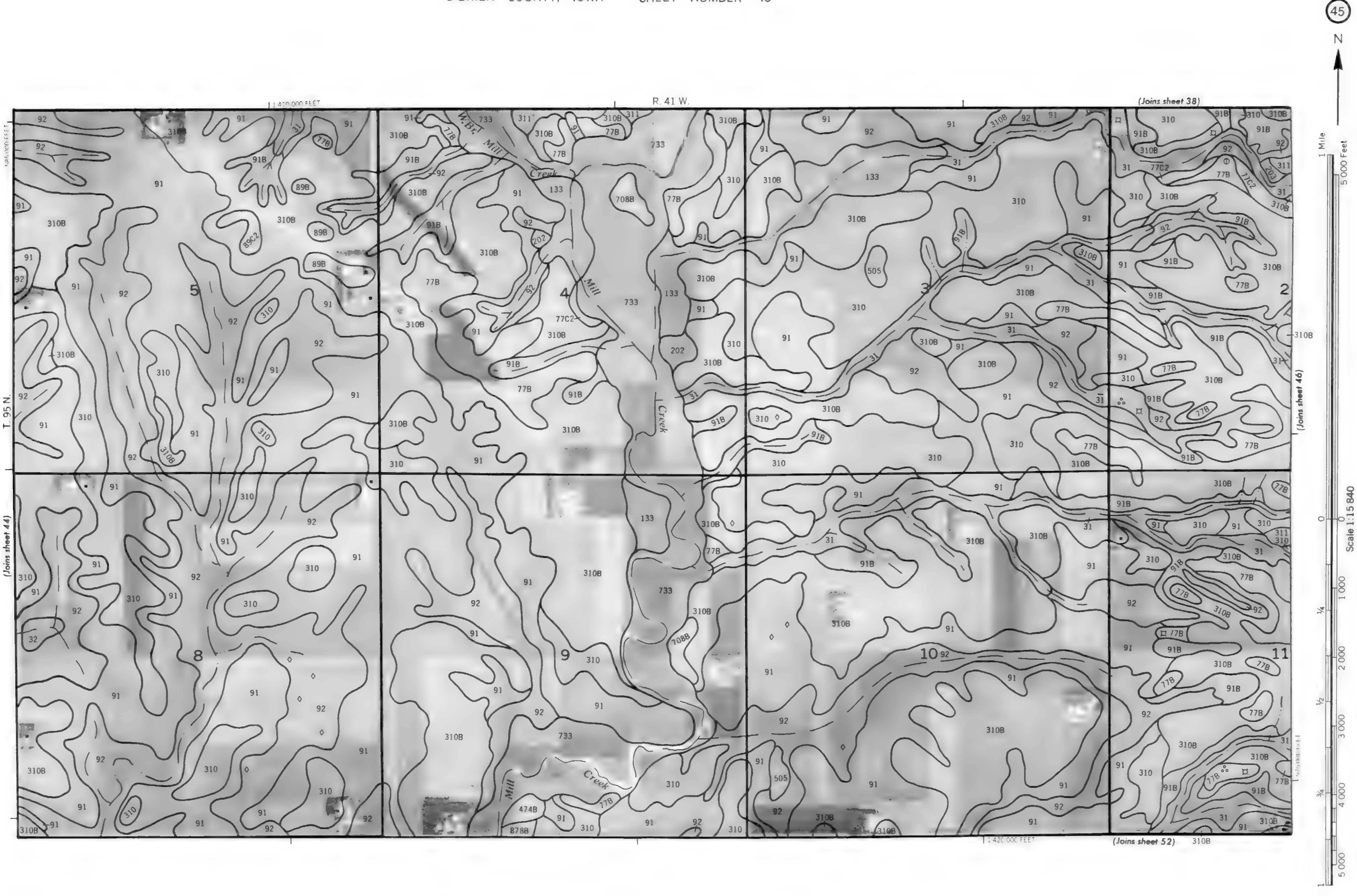

N
R. 40 W
R. 39 W
T. 96 N
(Joins sheet 34)
(Joins sheet 42)
(Joins sheet 48)
(Joins sheet 40)
25
30
29
28
36
31
32
33
Little Waterman Creek
Waterman Creek
McCready Creek
Creek
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000

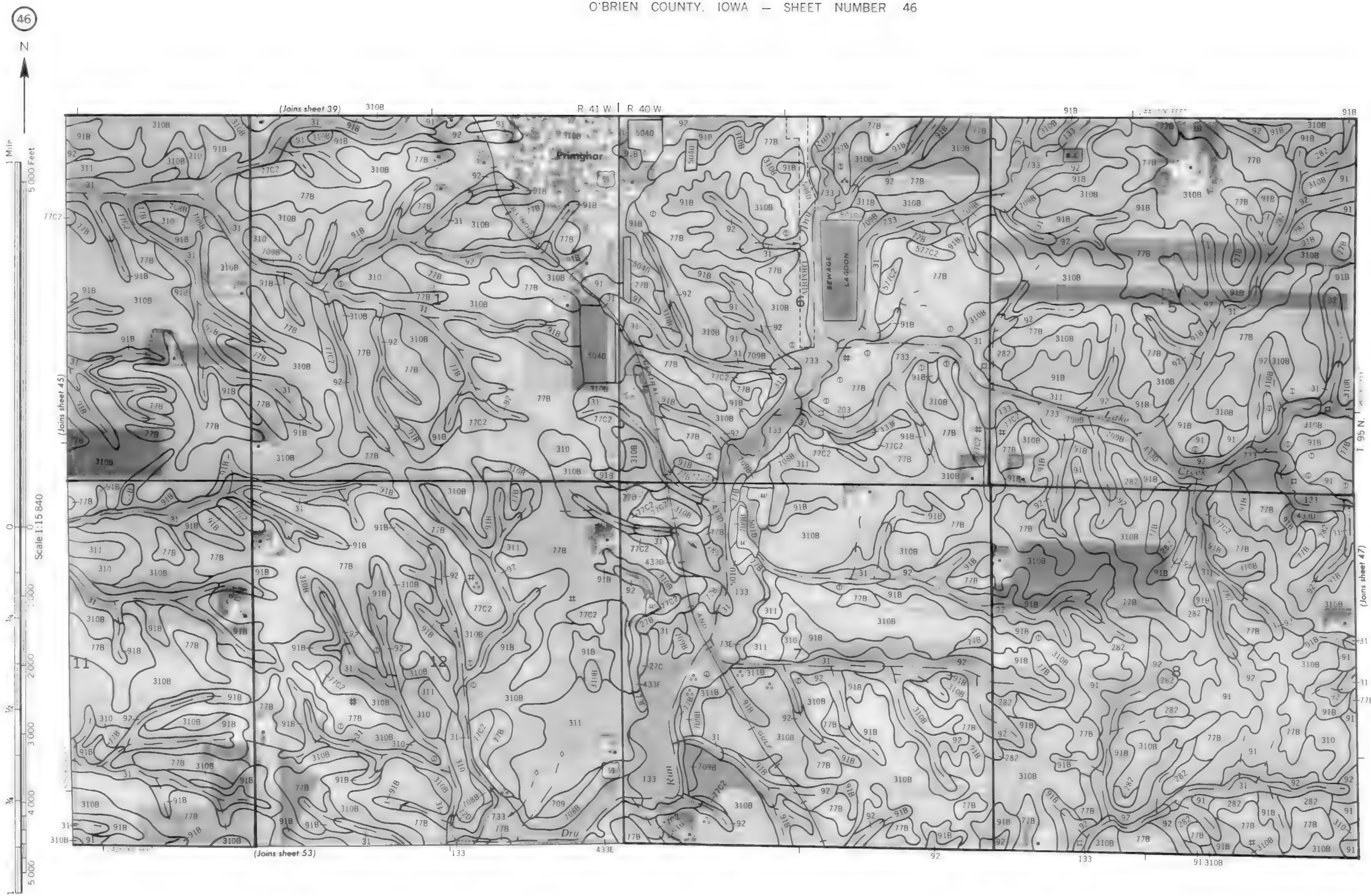

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 35)
(Joins sheet 41)
(Joins sheet 49)
R. 39 W.
T. 96 N.
1 495 000 FEET
1 480 000 FEET
27
26
25
34
35
36
Willow
Creek
CLAY COUNTY

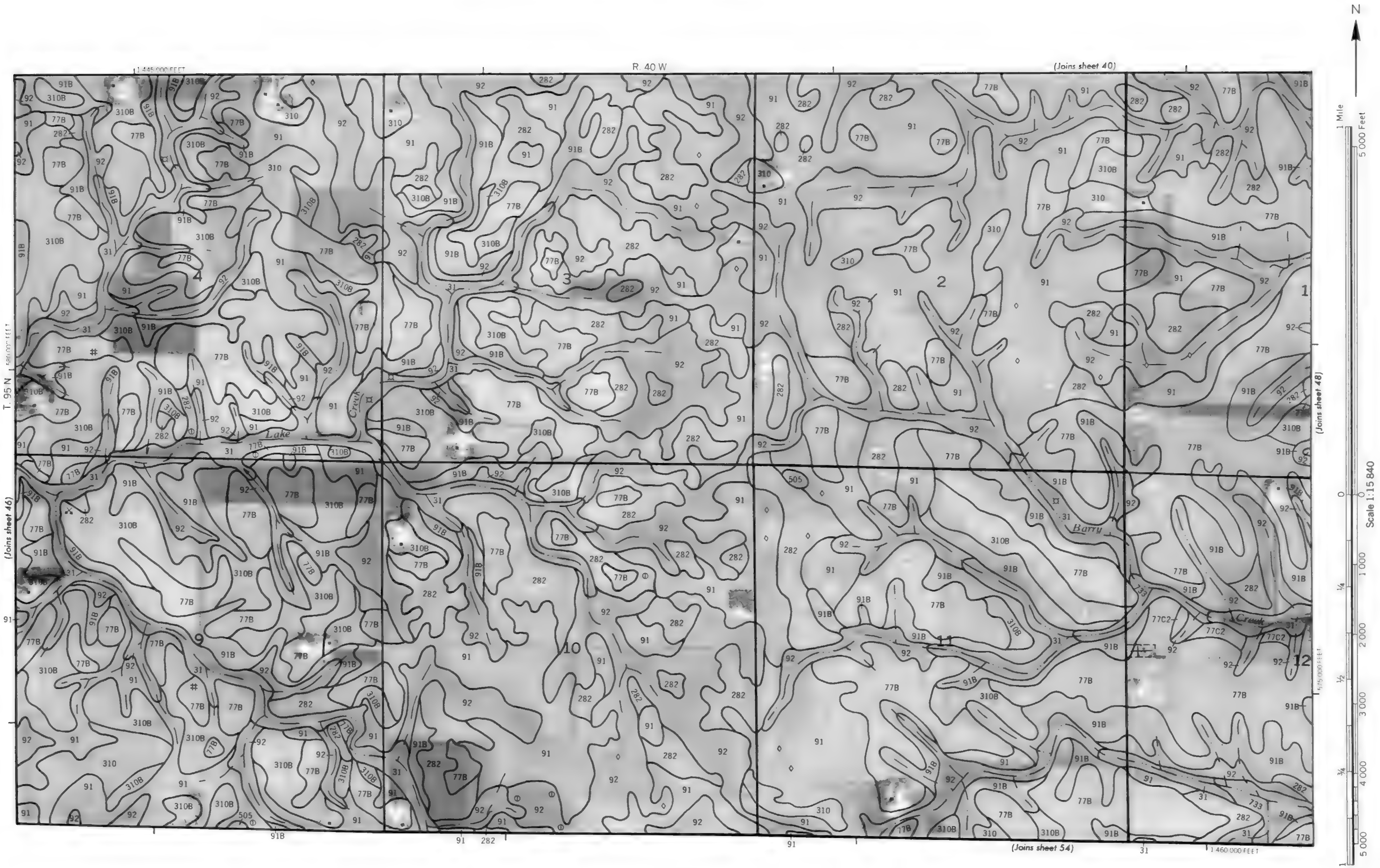


43
N
R. 42 W.
T. 95 N.
SIOUX COUNTY
(Joins sheet 36)
(Joins sheet 44)
(Joins sheet 50)
Willow Creek
Stofferan
Creek
Roetzel Creek
6
5
4
3
7
8
9
10
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000

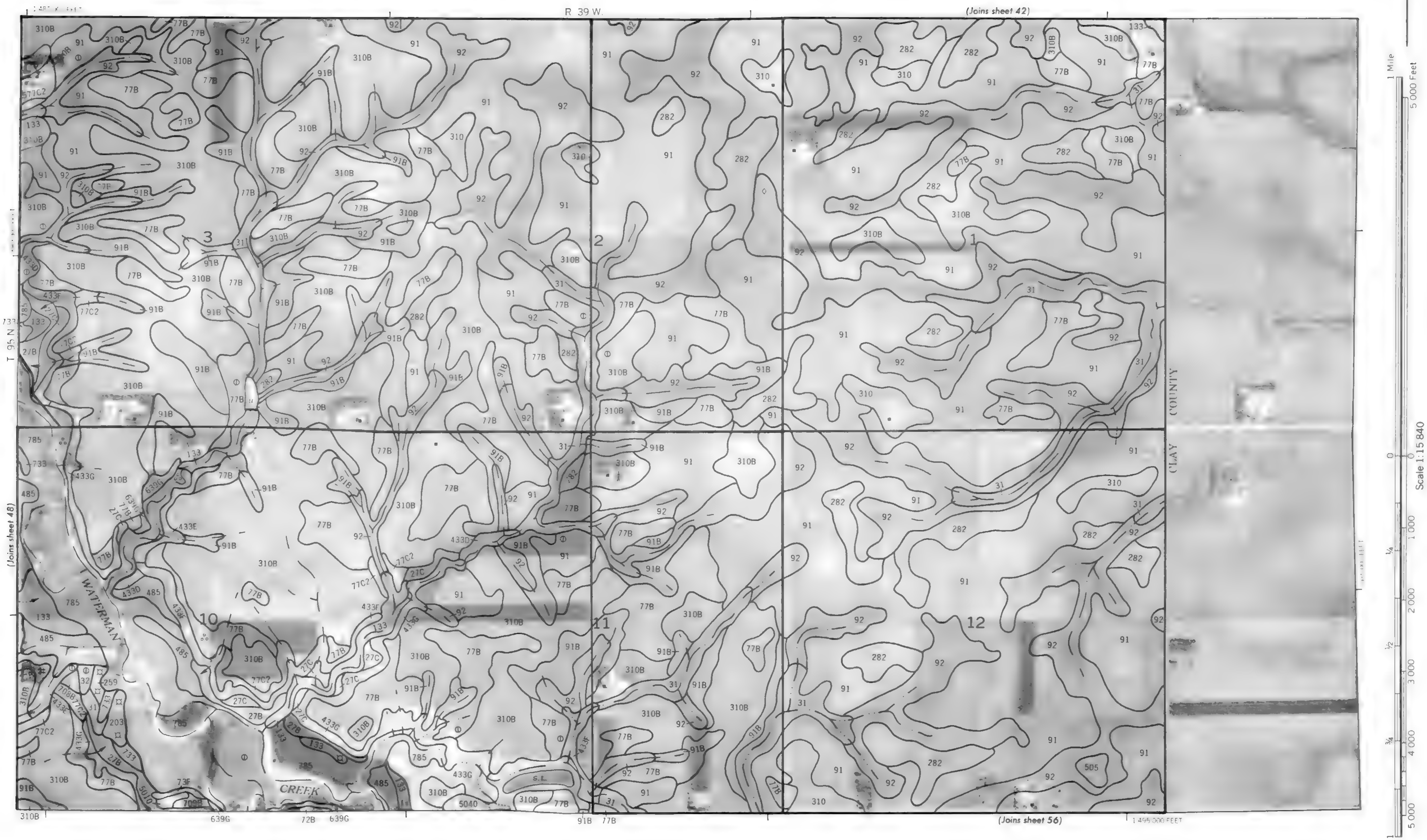

N
(Joins sheet 37)
(Joins sheet 43)
(Joins sheet 45)
(Joins sheet 51)
R. 42 W.
R. 41 W.
T. 95 N.
585 000 FEET
580 000 FEET
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000
1
2
6
7
10
11
12
Johnson
Creek

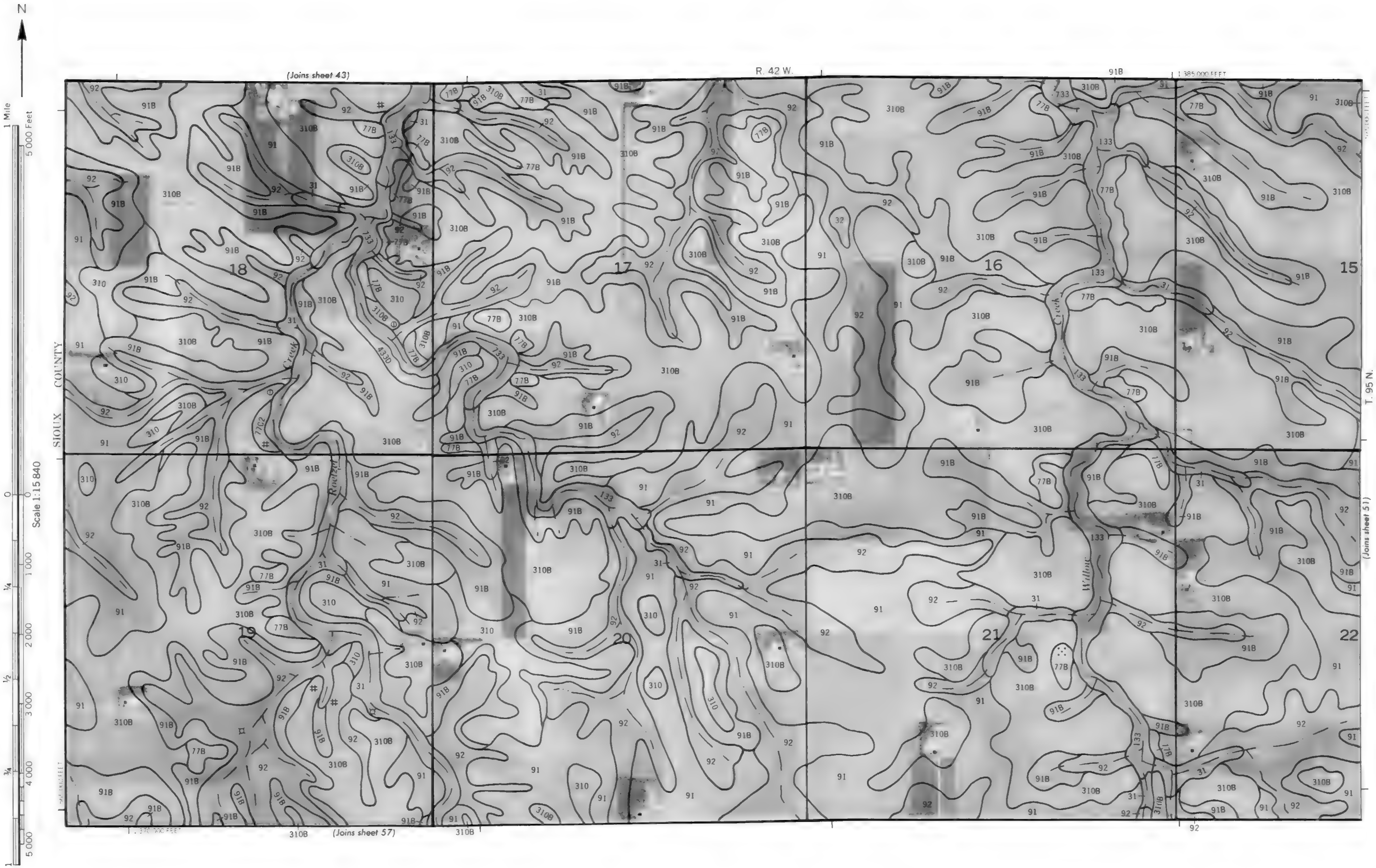

45
N
R. 41 W.
T. 95 N.
(Joins sheet 38)
(Joins sheet 44)
(Joins sheet 46)
(Joins sheet 52)
1 410 000 FEET
1 420 000 FEET
W. Br. Mill Creek
Mill Creek
Creek
Mill
5
4
3
2
8
9
10
11
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000

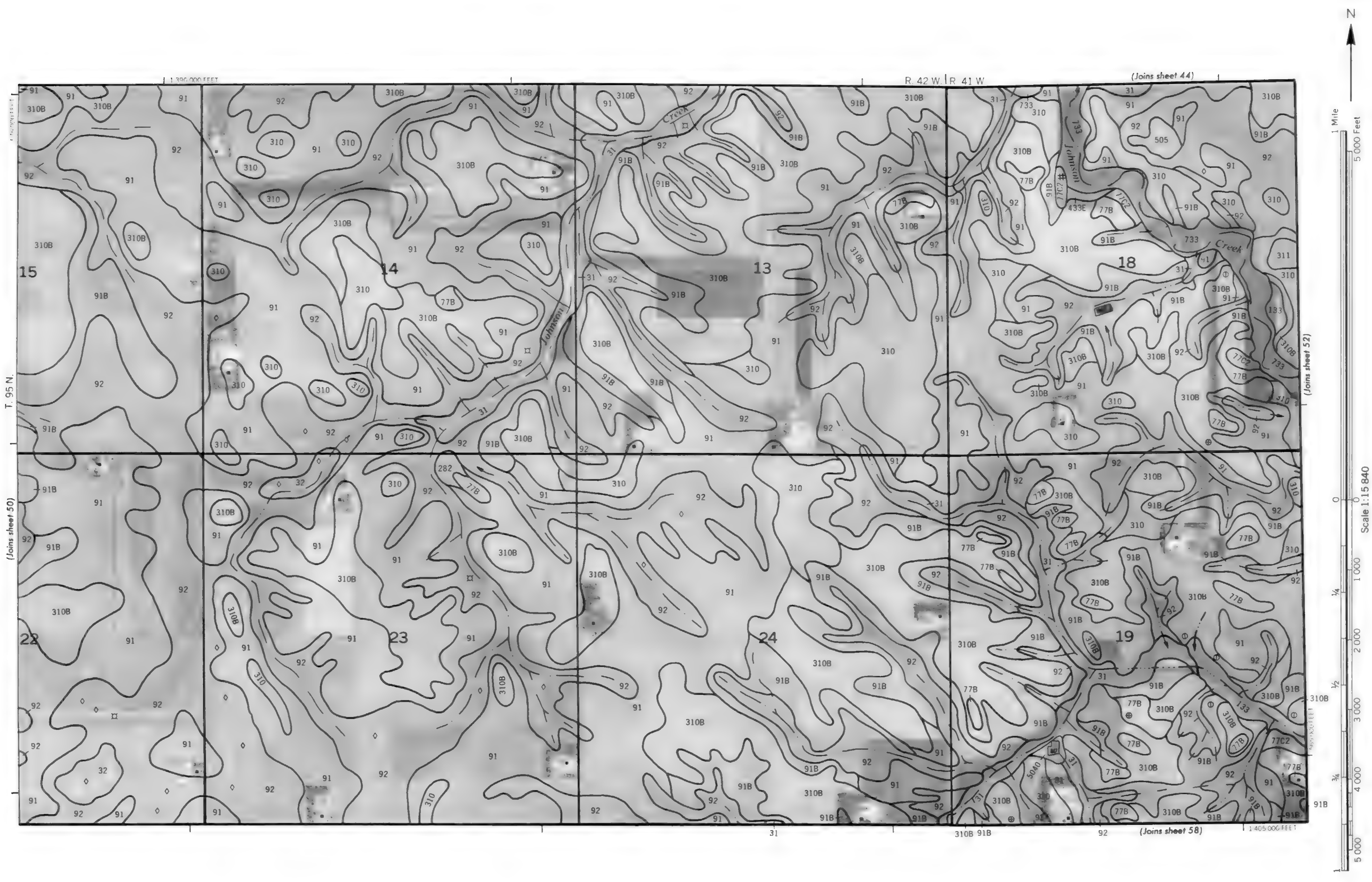

46
N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 39)
R 41 W
R 40 W
Primghar
SEWAGE LAGOON
Lake
Creek
Run
Dry
(Joins sheet 45)
(Joins sheet 47)
(Joins sheet 53)
T. 95 N.

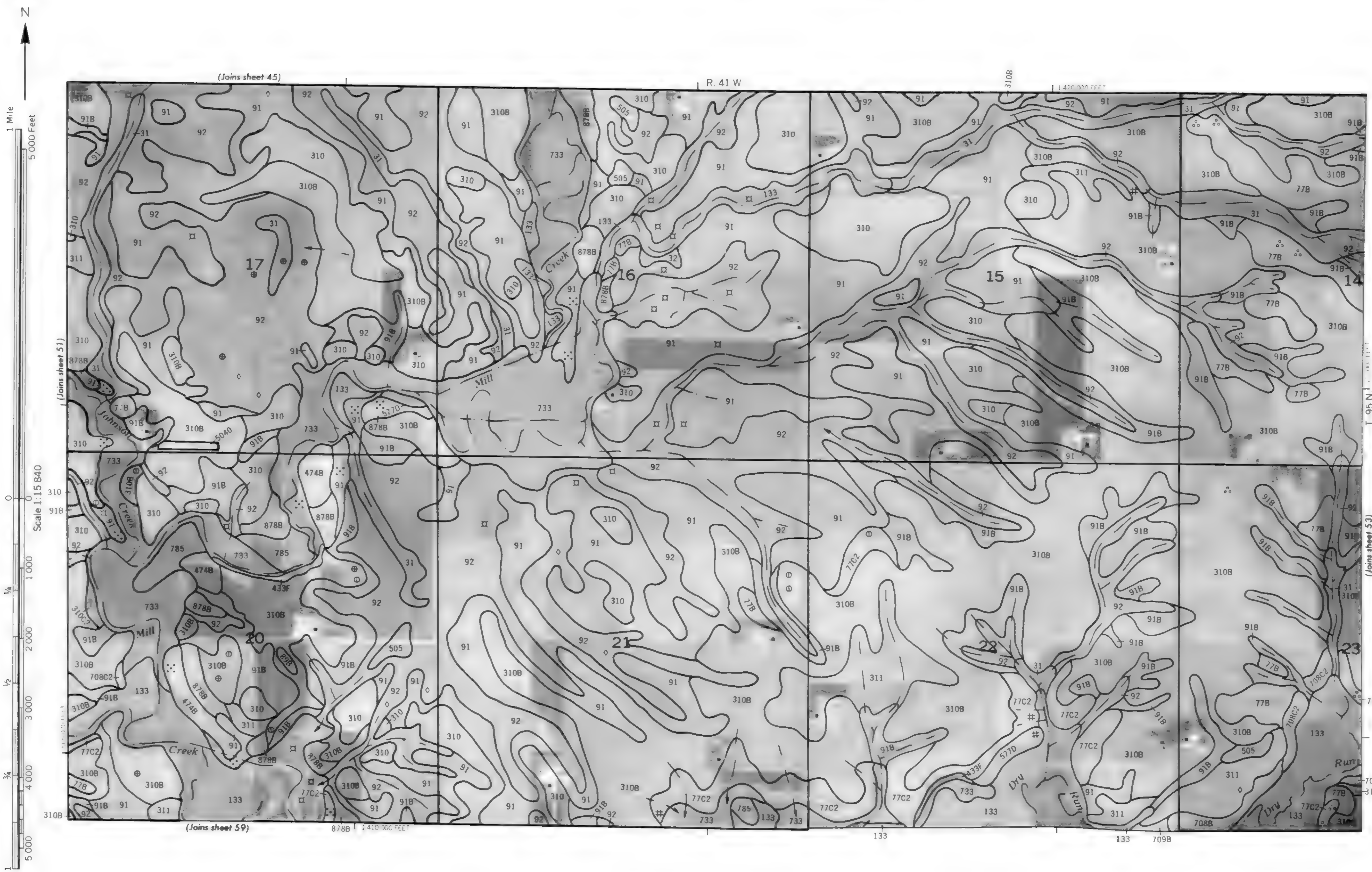

R. 40 W
(Joins sheet 40)
(Joins sheet 46)
(Joins sheet 48)
(Joins sheet 54)
T. 95 N
1 445 000 FEET
1 460 000 FEET
Lake
Creek
Barry
Creek
N
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
R. 40 W.
R. 39 W.
(Joins sheet 41)
(Joins sheet 47)
(Joins sheet 49)
(Joins sheet 55)
T. 95 N.
Little
Waterman Creek
WATERWAY
CREEK
McCrath
Creek
Barry
Creek

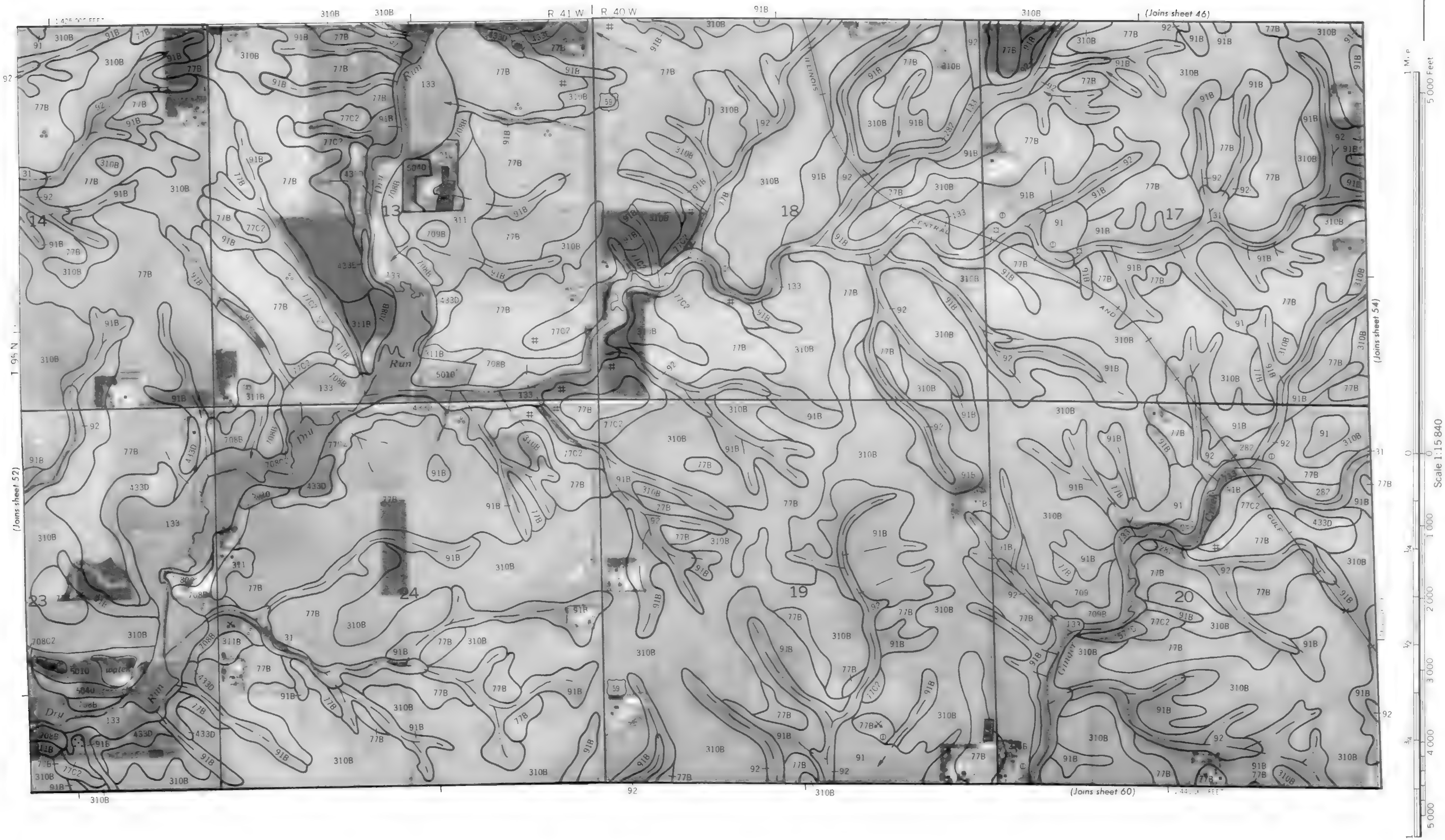

N
R 39 W.
(Joins sheet 42)
(Joins sheet 48)
(Joins sheet 56)
T 95 N
CLAY COUNTY
WATERMAN
CREEK
1 Mile
5 000 Feet
Scale 1:15 840

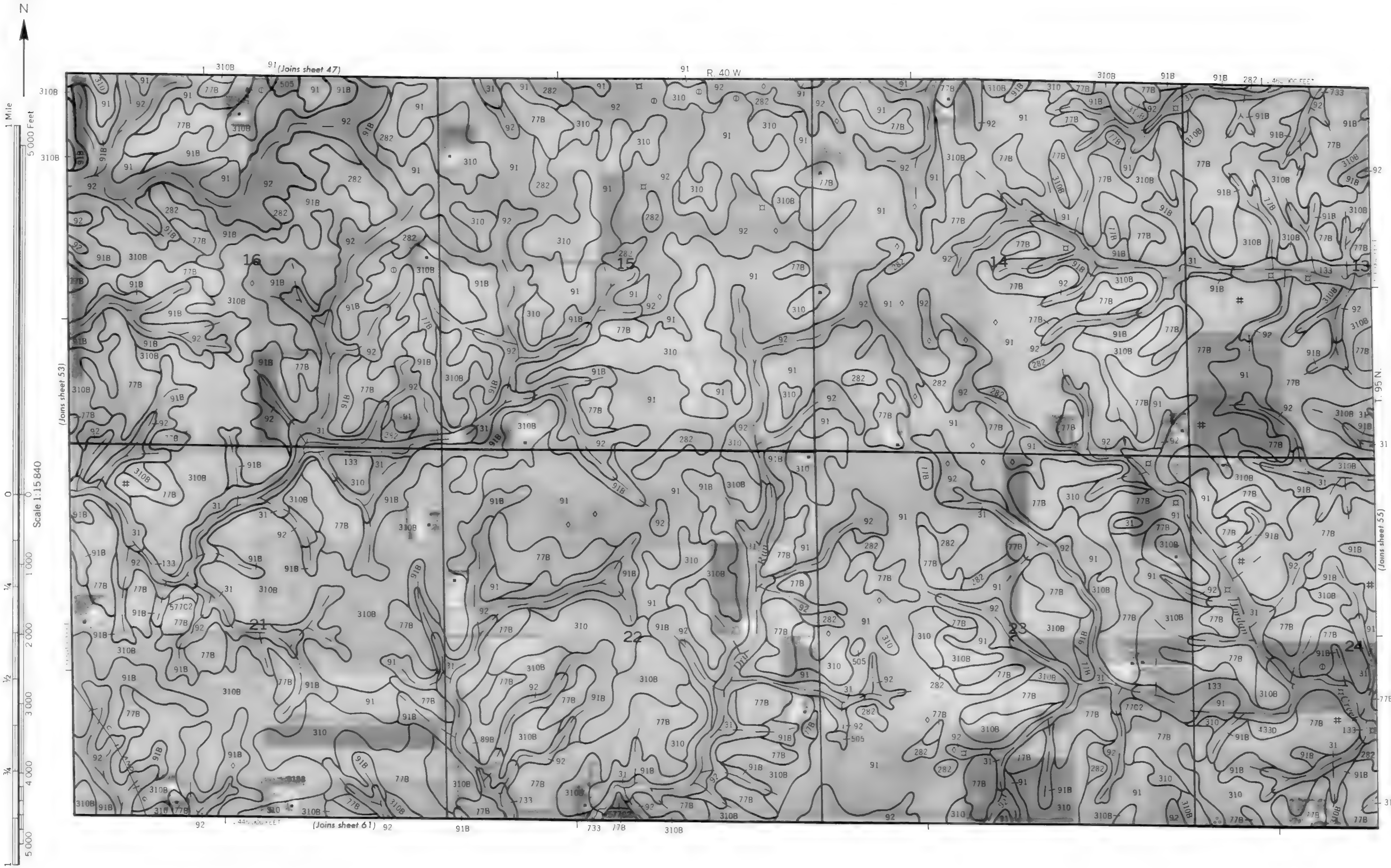

N
(Joins sheet 43)
R. 42 W.
T. 95 N.
(Joins sheet 51)
(Joins sheet 57)
SIOUX COUNTY
18
17
16
15
19
20
21
22
Scale 1:15 840
1 Mile
5 000 Feet
Rock Creek
Willow Creek

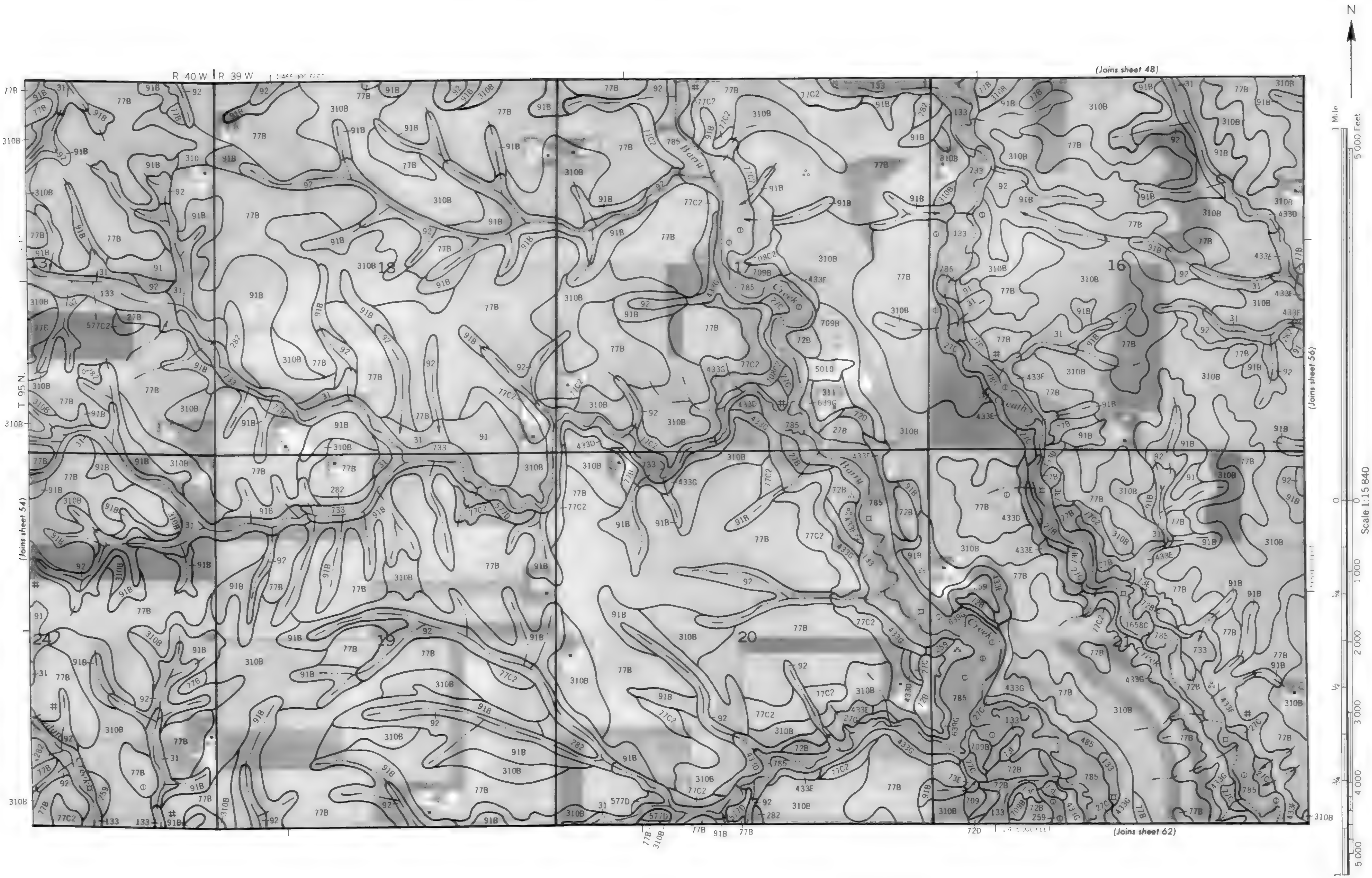

N
(Joins sheet 44)
R. 42 W.
R. 41 W.
T. 95 N.
(Joins sheet 50)
(Joins sheet 52)
(Joins sheet 58)
Johnson
Creek
15
14
13
18
22
23
24
19
1 Mile
5 000 Feet
Scale 1:15 840

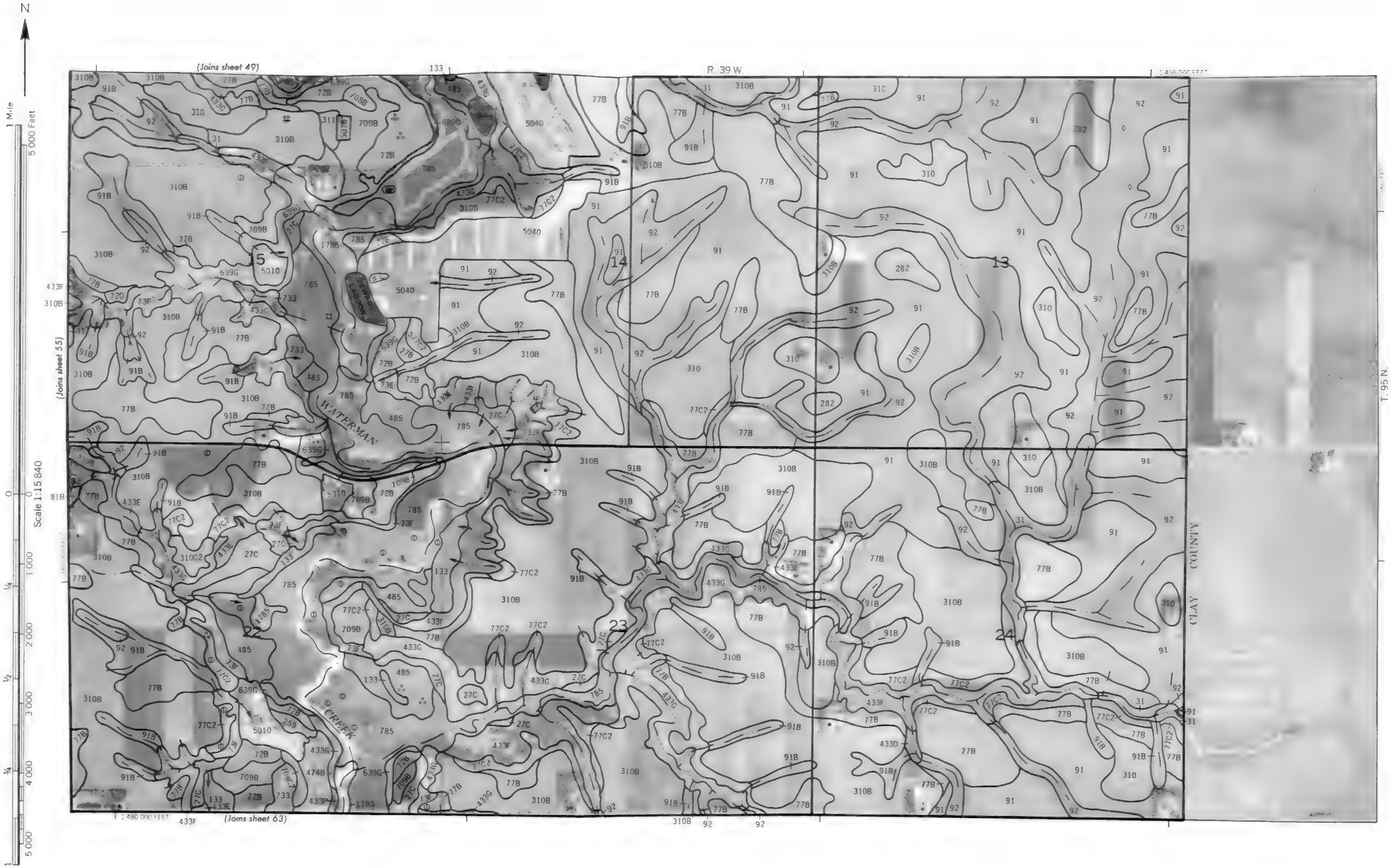

N
(Joins sheet 45)
R. 41 W
1 420 000 FEET
(Joins sheet 51)
(Joins sheet 53)
(Joins sheet 59)
1 410 000 FEET
T. 95 N.
17
16
15
14
20
21
22
23
Johnson
Creek
Mill
Creek
Mill
Creek
Dry
Run
Dry Run
1 Mile
5 000 Feet
Scale 1:15 840

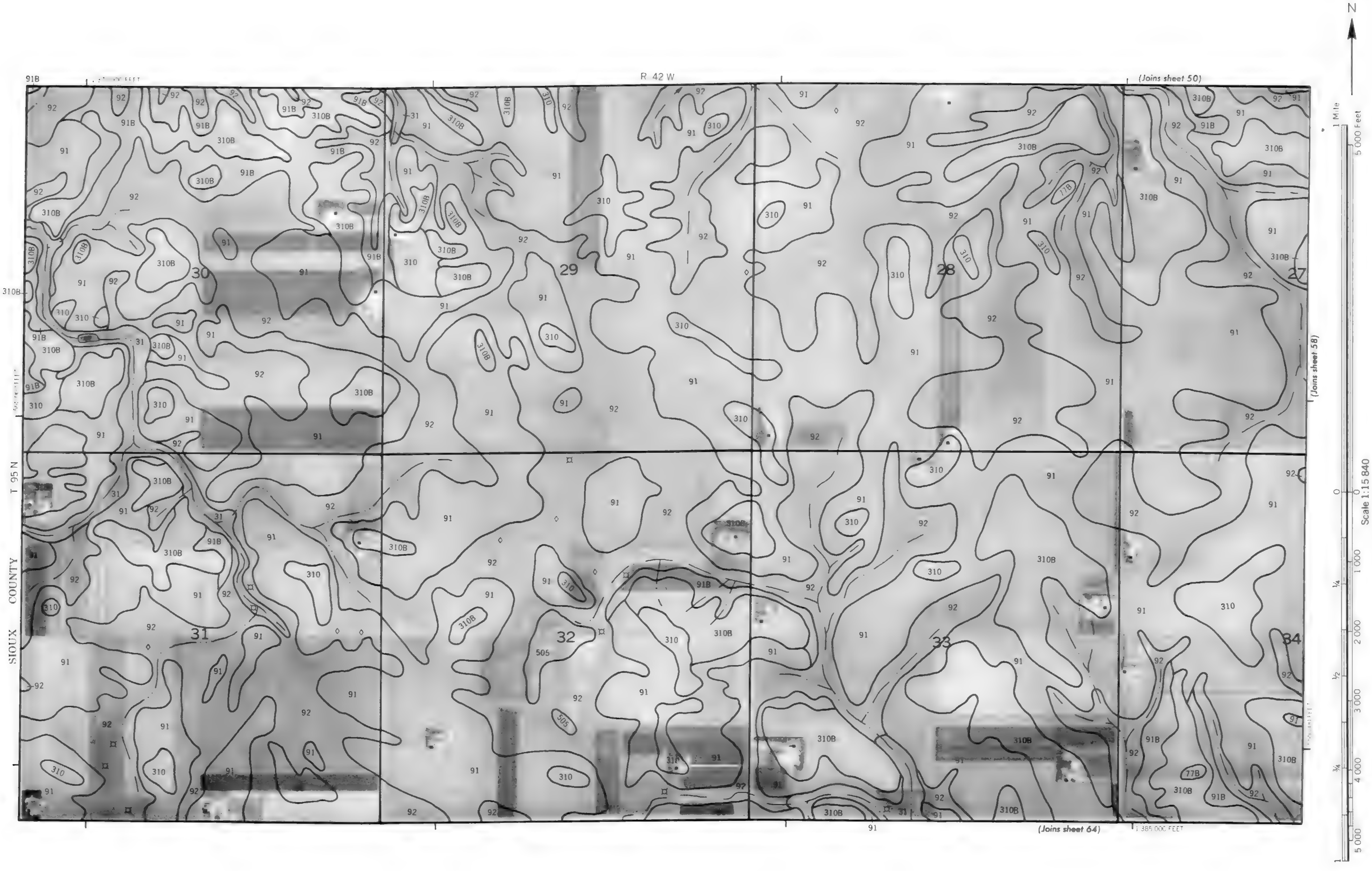
53

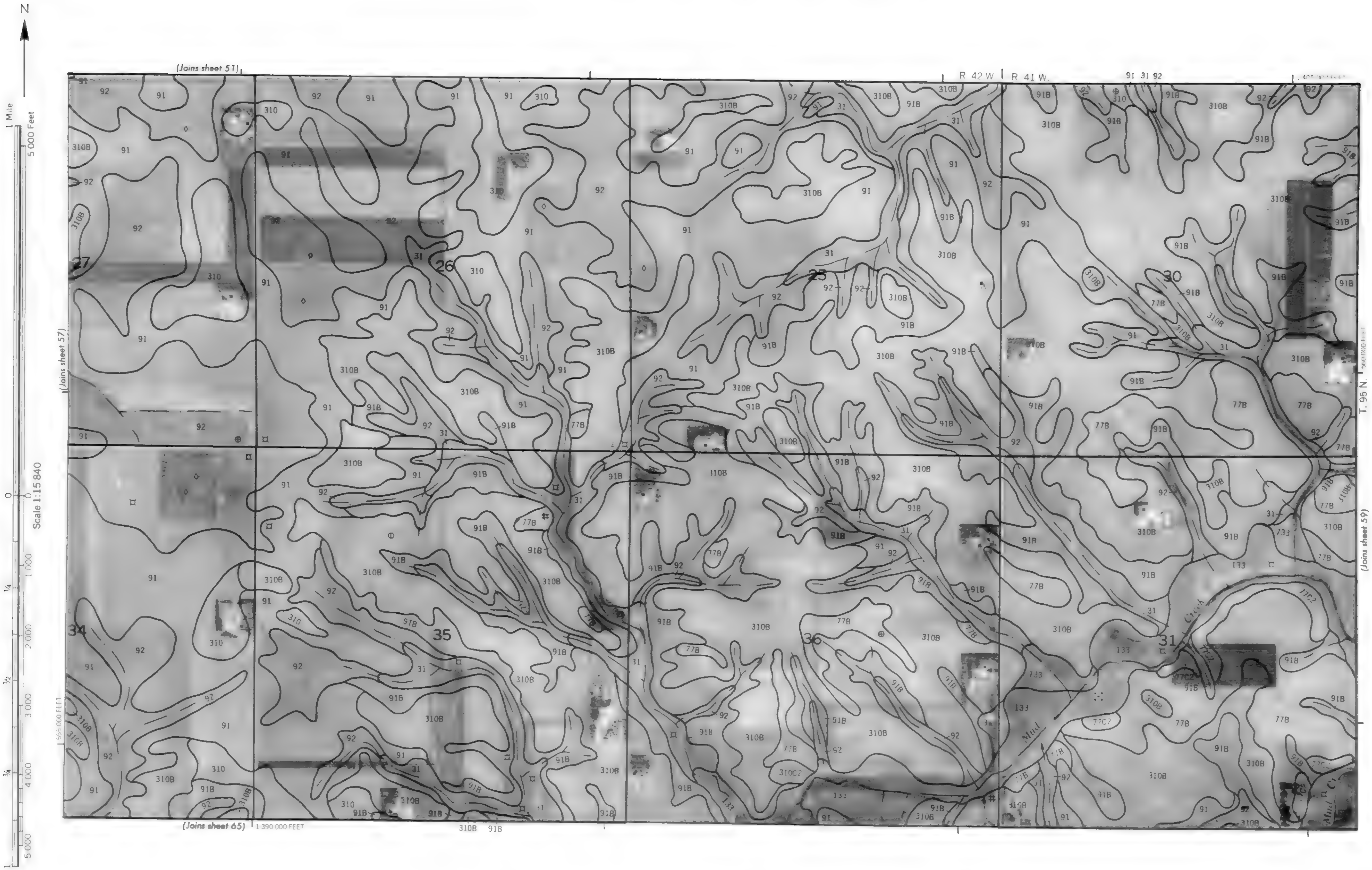

N
(Joins sheet 46)
(Joins sheet 52)
(Joins sheet 54)
(Joins sheet 60)
R. 41 W.
R. 40 W.
T. 94 N.
13
14
17
18
19
20
23
24
Dry Run
Cinder
ILLINOIS CENTRAL AND GULF
59
water
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 47)
(Joins sheet 53)
(Joins sheet 55)
(Joins sheet 61)
R. 40 W
T. 95 N.
16
15
14
13
21
22
23
24

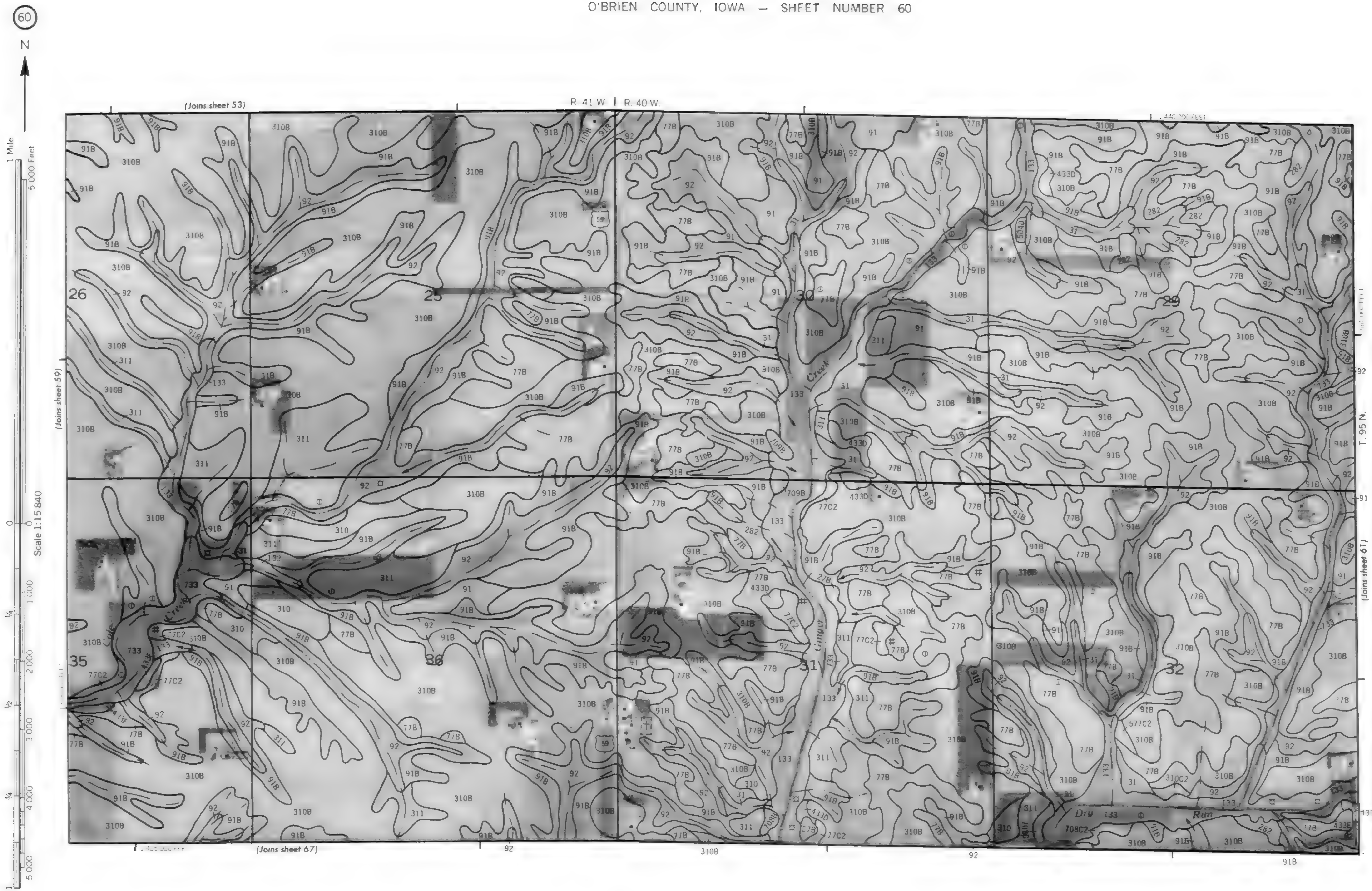

N
(Joins sheet 48)
(Joins sheet 54)
(Joins sheet 56)
(Joins sheet 62)
R 40 W
R 39 W
T 95 N.
13
18
17
16
24
19
20
21
Barry Creek
Creath
1 Mile
5 000 Feet
Scale 1:15 840
0
1000
2000
3000
4000
5000

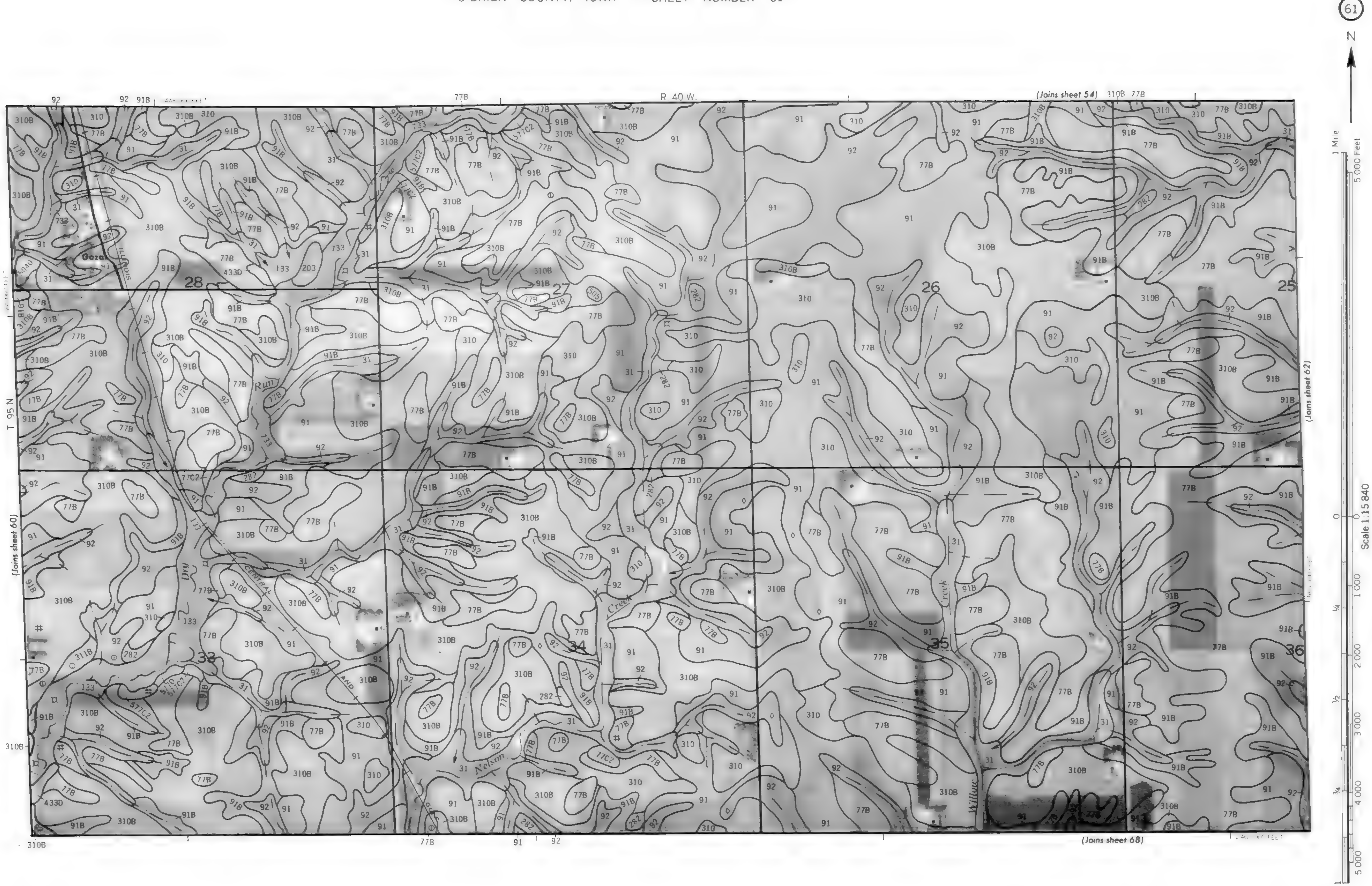

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 49)
R. 39 W.
T. 95 N.
(Joins sheet 55)
(Joins sheet 63)
CLAY COUNTY
WATERMAN
CREEK
SEWAGE LAGOONS
15
14
13
22
23
24

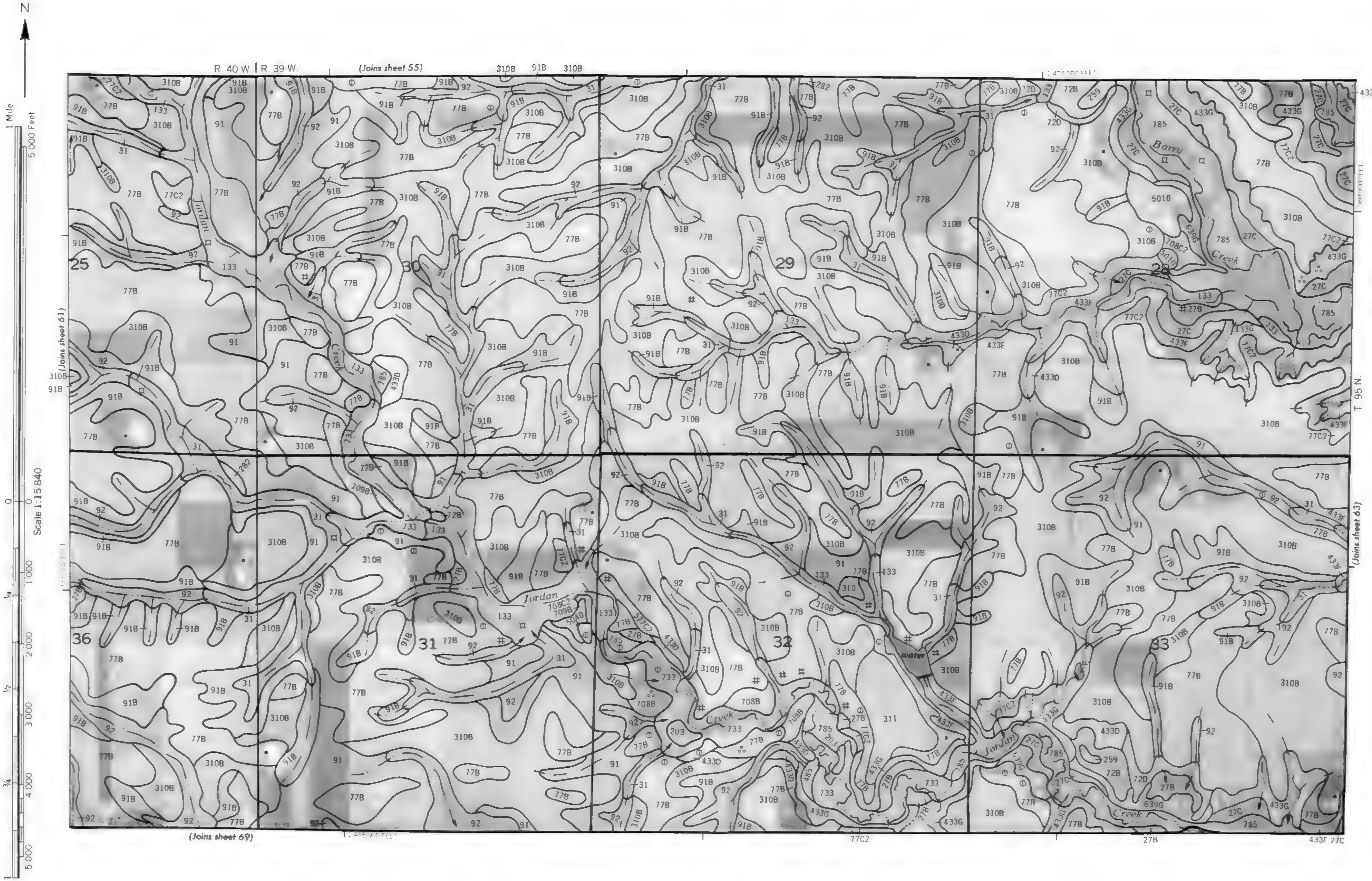

N
R 42 W
(Joins sheet 50)
(Joins sheet 58)
(Joins sheet 64)
T 95 N
SIOUX COUNTY
29
28
27
30
31
32
33
34
1 385 000 FEET
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
1/4
1/2
3/4
1

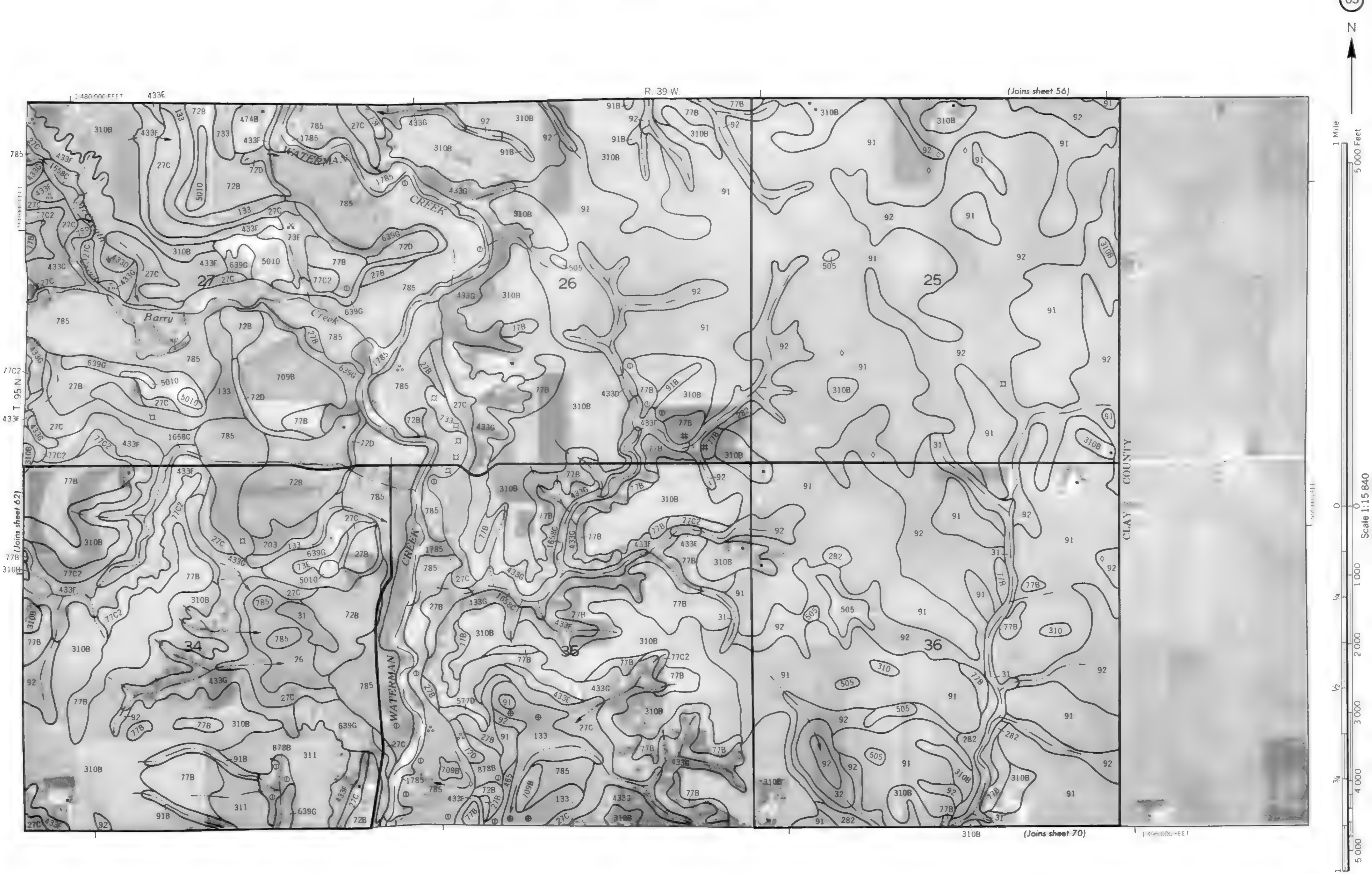

N
(Joins sheet 51)
R 42 W
R 41 W
T. 95 N.
(Joins sheet 57)
(Joins sheet 59)
(Joins sheet 65)
1 390 000 FEET
555 000 FEET
560 000 Feet
27
26
25
30
34
35
36
31
Mud Creek
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
¼
½
¾
1

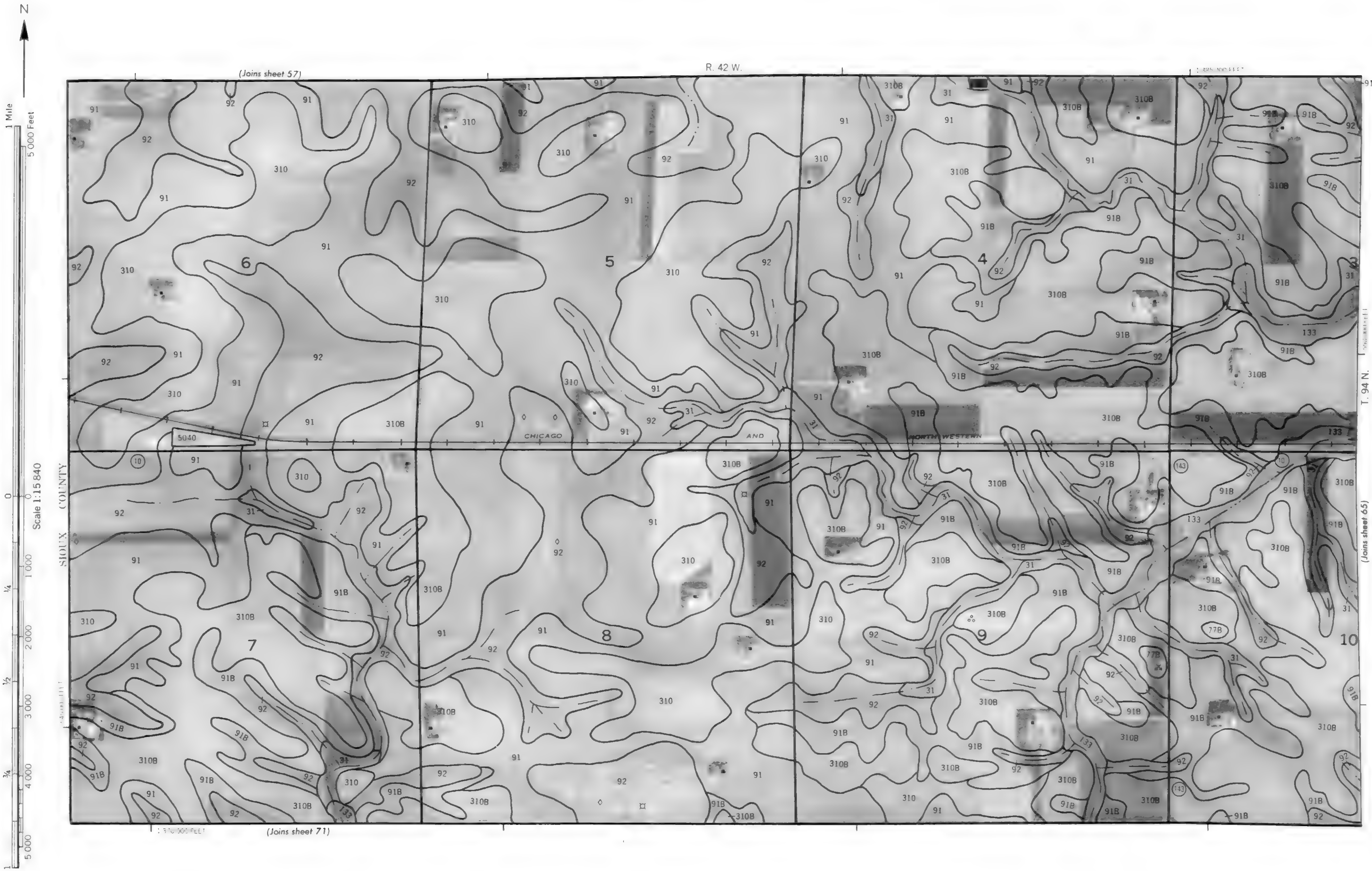

59
N
R. 41 W.
T. 95 N.
(Joins sheet 52)
(Joins sheet 60)
(Joins sheet 66)
(Joins sheet 57)
Scale 1:15 840
1 Mile
5 000 Feet
Dry Run
Mill Creek
Mud Creek
Cole Creek
28
29
27
26
32
33
34
35

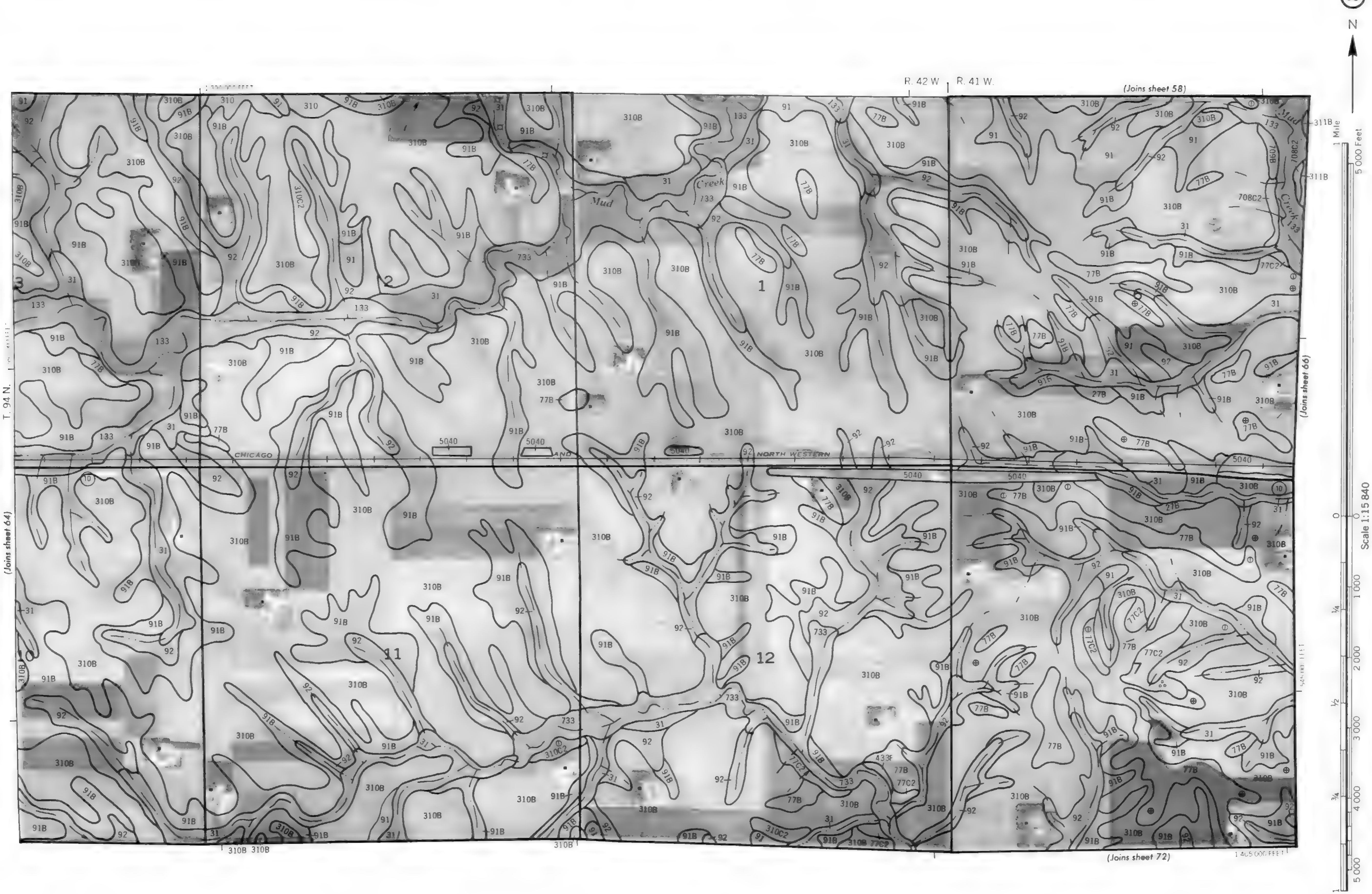

60
N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 53)
R. 41 W.
R. 40 W.
T. 95 N.
(Joins sheet 59)
(Joins sheet 61)
(Joins sheet 67)
26
25
30
29
35
36
31
32
Creek
Ginger
Dry Run
Cedar Creek

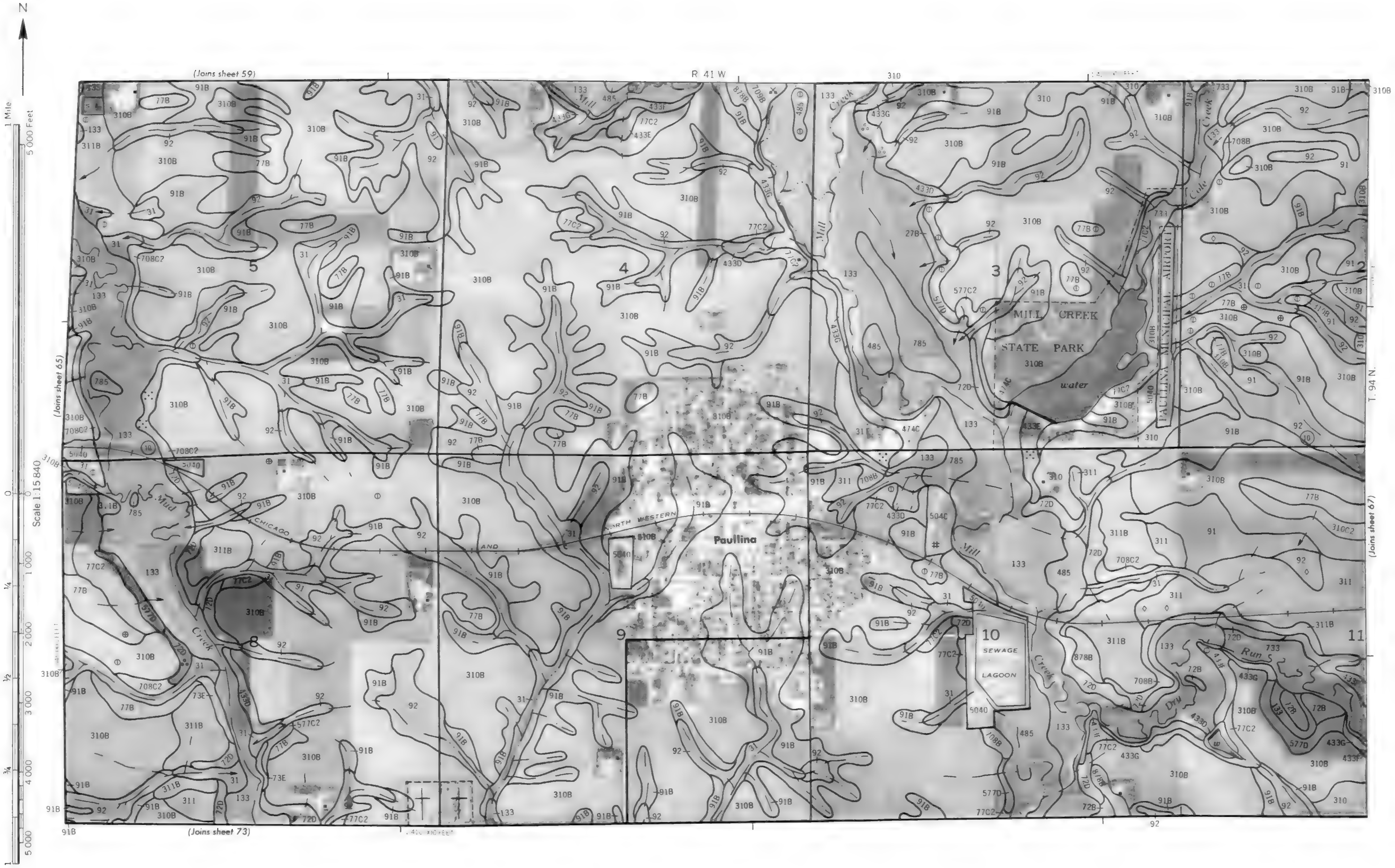

61
N
R. 40 W.
(Joins sheet 54)
T 95 N.
(Joins sheet 60)
(Joins sheet 62)
(Joins sheet 68)
Gaza
Dry Run
Nelson Creek
Willow Creek
28
27
26
25
33
34
35
36
1 Mile
5 000 Feet
Scale 1:15 840

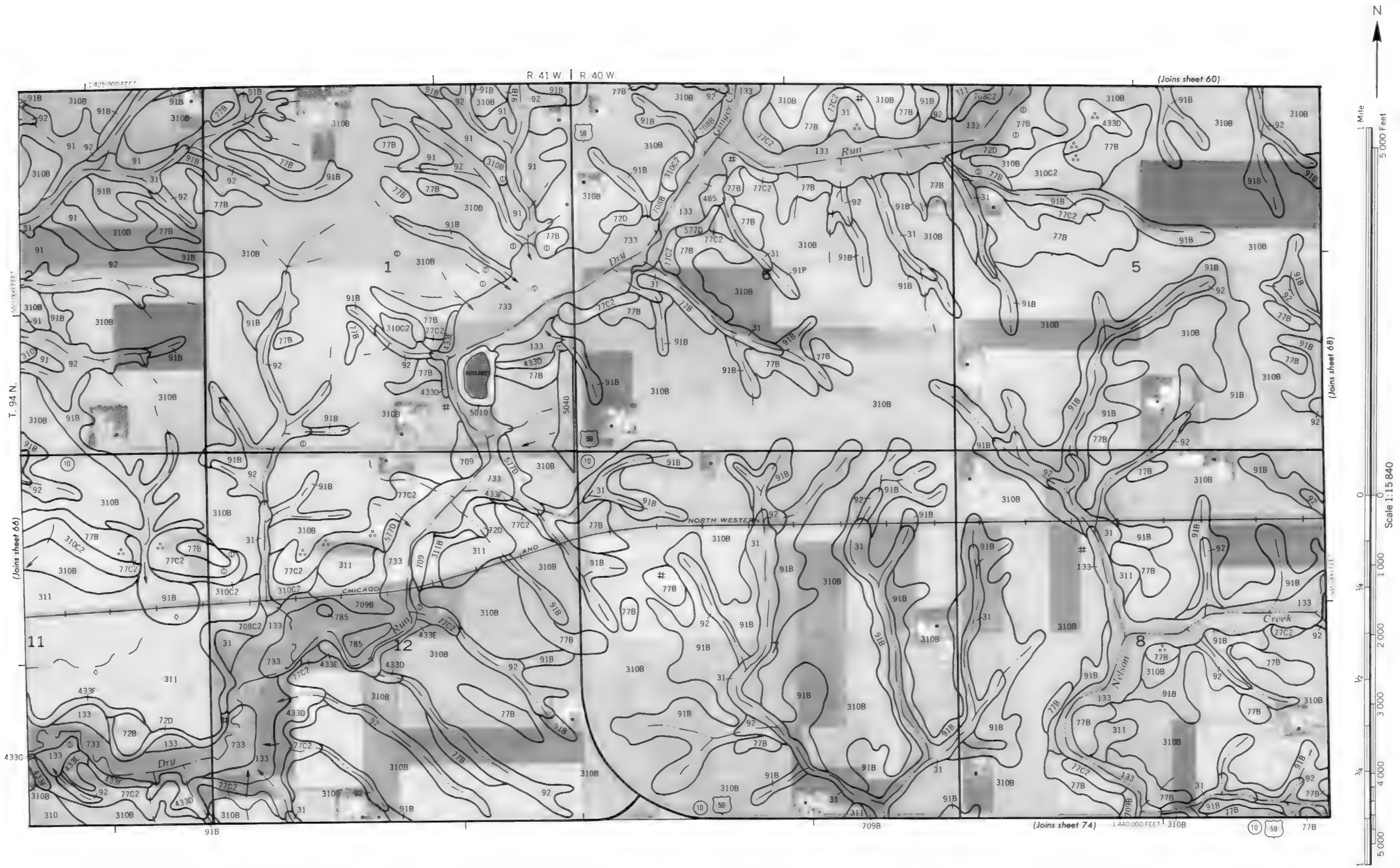

N
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
¼
½
¾
1
R. 40 W. | R. 39 W.
(Joins sheet 55)
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 69)
T. 95 N.
25
30
29
28
36
31
32
33
Jordan
Creek
Barry
Creek
Jordan
Creek
water

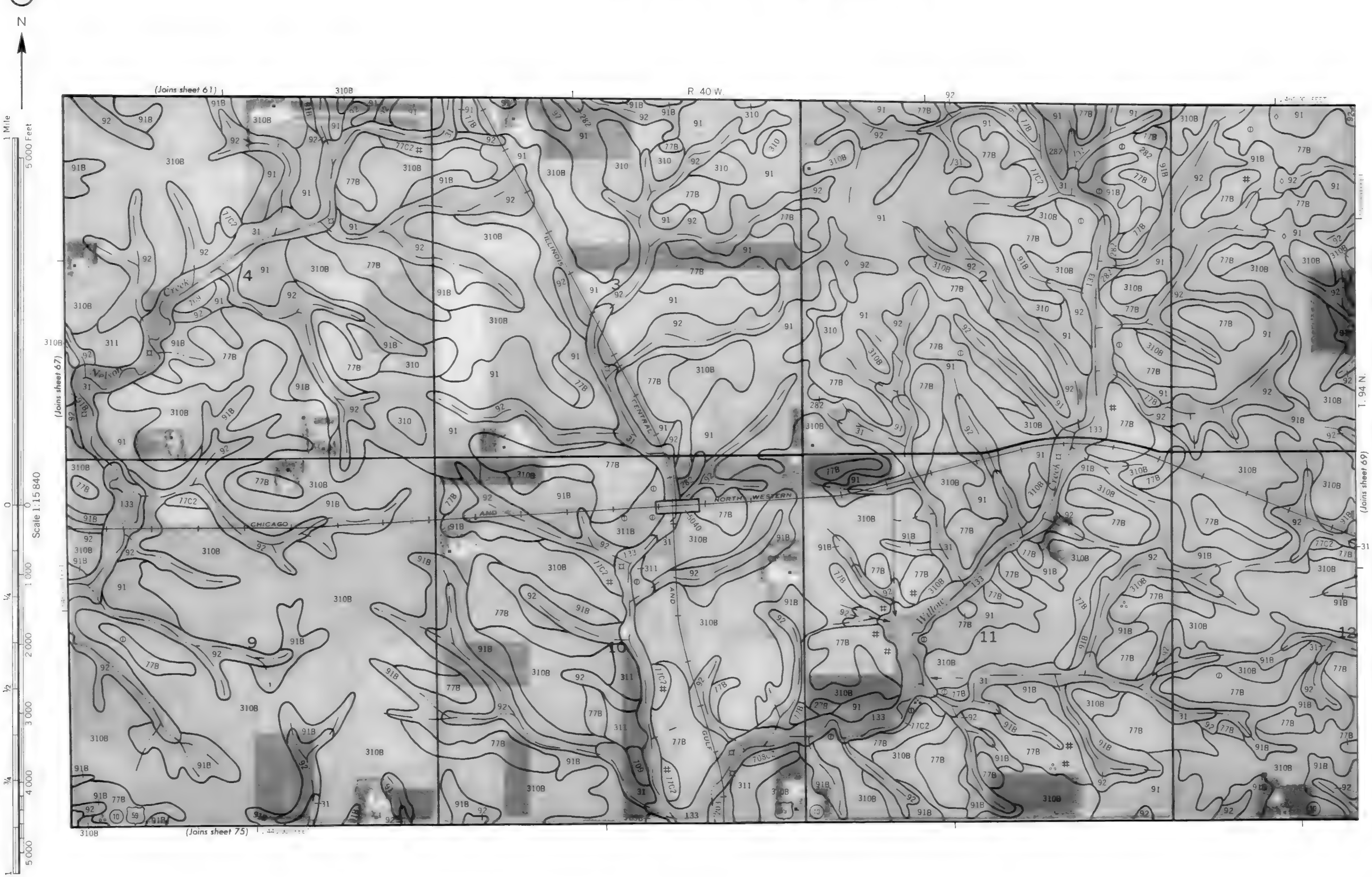

63
N
R. 39 W.
(Joins sheet 56)
(Joins sheet 62)
(Joins sheet 70)
T. 95 N
CLAY COUNTY
WATERMAN CREEK
Barry Creek
27
26
25
34
35
36
1 Mile
5 000 Feet
Scale 1:15 840
1 000
2 000
3 000
4 000
5 000


N
(Joins sheet 57)
R. 42 W.
T. 94 N.
(Joins sheet 65)
(Joins sheet 71)
SIOUX COUNTY
CHICAGO
AND
NORTH WESTERN
1 Mile
5 000 Feet
Scale 1:15 840
0
1 000
2 000
3 000
4 000
5 000
¼
½
¾
1
6
5
4
3
7
8
9
10


65
N
R. 42 W.
R. 41 W.
(Joins sheet 58)
(Joins sheet 64)
(Joins sheet 66)
(Joins sheet 72)
T. 94 N.
Mud
Creek
CHICAGO
AND
NORTH WESTERN
1 Mile
5 000 Feet
Scale 1:15 840
0
1000
2000
3000
4000
5000
1/4
1/2
3/4
1
2
6
10
11
12

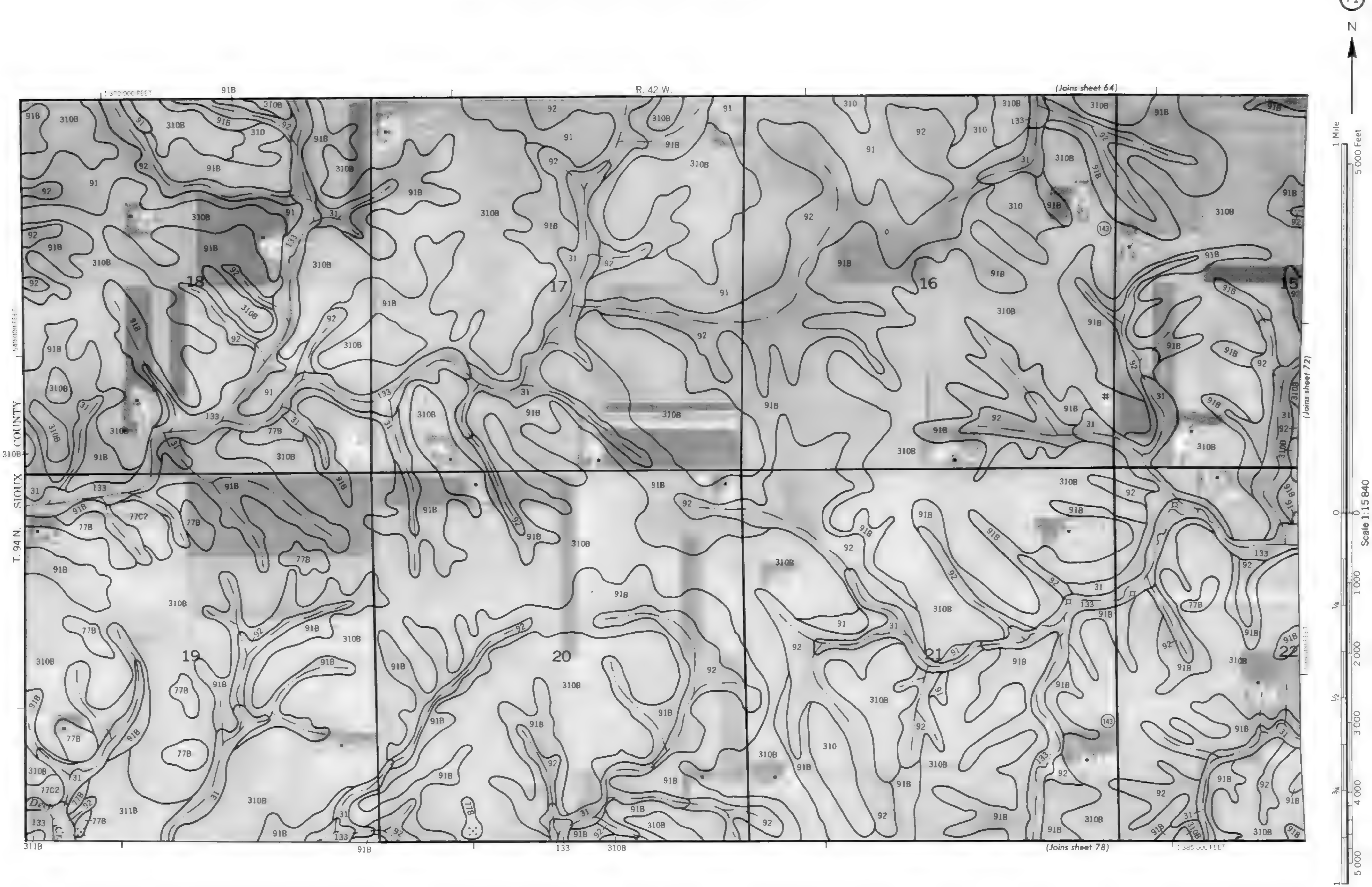

N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 59)
(Joins sheet 65)
(Joins sheet 67)
(Joins sheet 73)
R. 41 W.
T. 94 N.
Paullina
MILL CREEK
STATE PARK
water
PAULLINA MUNICIPAL AIRPORT
SEWAGE
LAGOON
CHICAGO AND NORTH WESTERN
Mill Creek
Mud Creek
Cole Creek
Dry Run
1
2
3
4
5
8
9
10
11

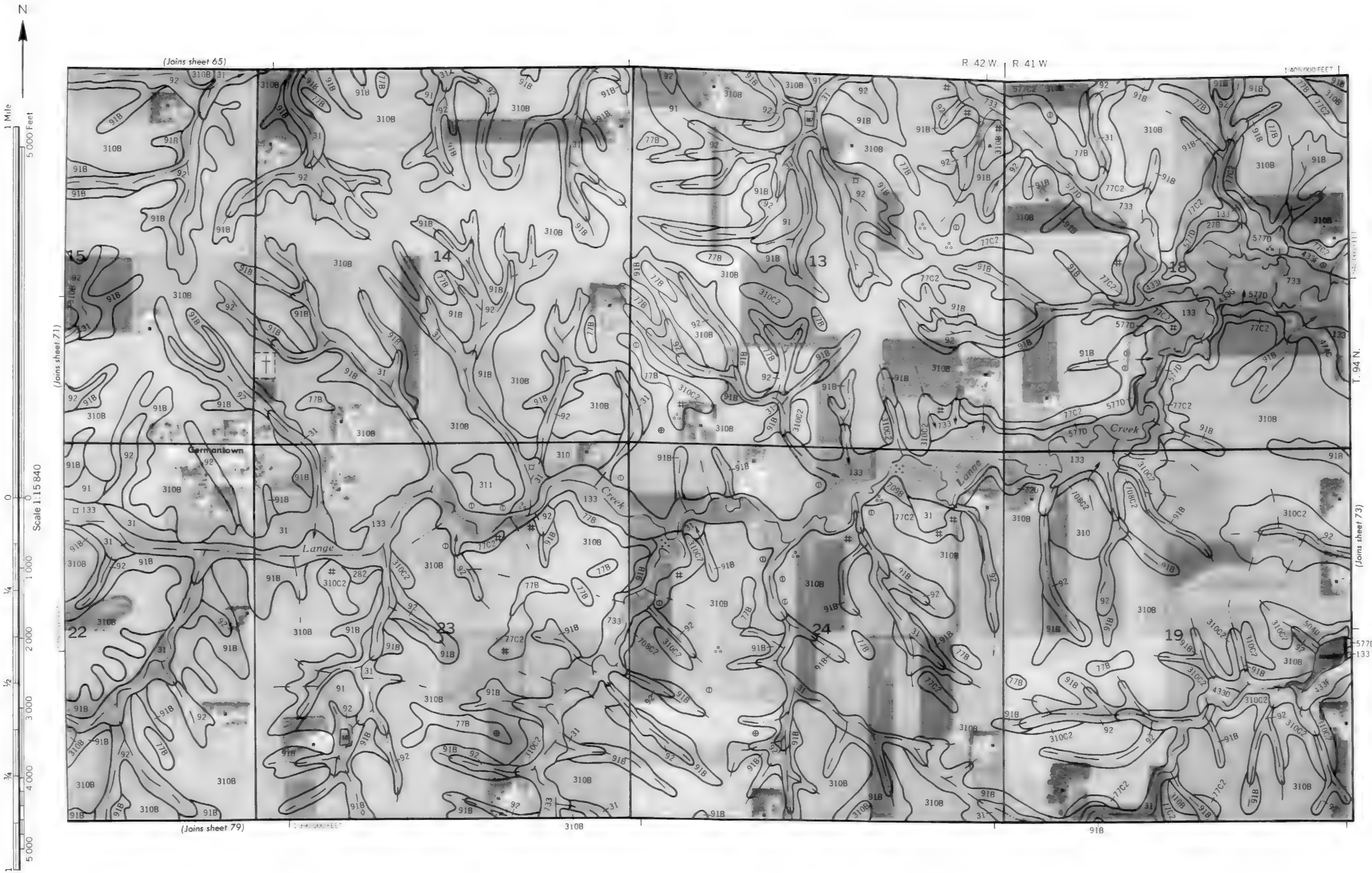

N
R. 41 W.
R. 40 W.
T. 94 N.
(Joins sheet 60)
(Joins sheet 68)
(Joins sheet 74)
(Joins sheet 66)
Dry Run
Nelson Creek
NORTH WESTERN
CHICAGO AND
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 61)
R. 40 W.
T. 94 N.
(Joins sheet 67)
(Joins sheet 69)
(Joins sheet 75)
CHICAGO AND NORTH WESTERN
ILLINOIS CENTRAL AND GULF
Nelson Creek
Willow Creek
2
3
4
9
10
11
12

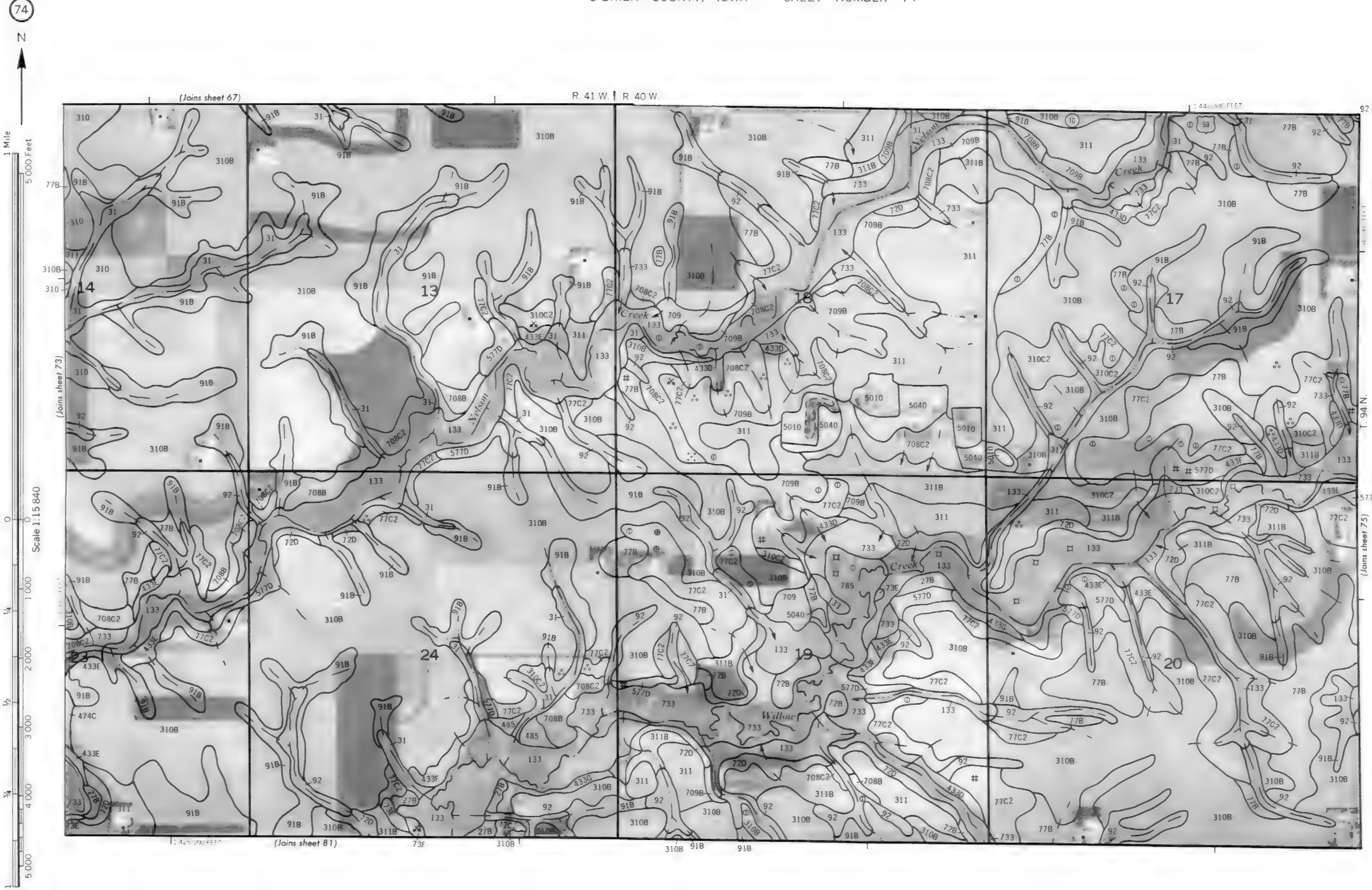

N
R 40 W
R 39 W
T 94 N
(Joins sheet 62)
(Joins sheet 70)
(Joins sheet 76)
(Joins sheet 68)
Sutherland
Murray
Creek
Jordan
CHICAGO AND NORTH WESTERN
SEWAGE LAGOON
1 Mile
5 000 Feet
Scale 1:15 840

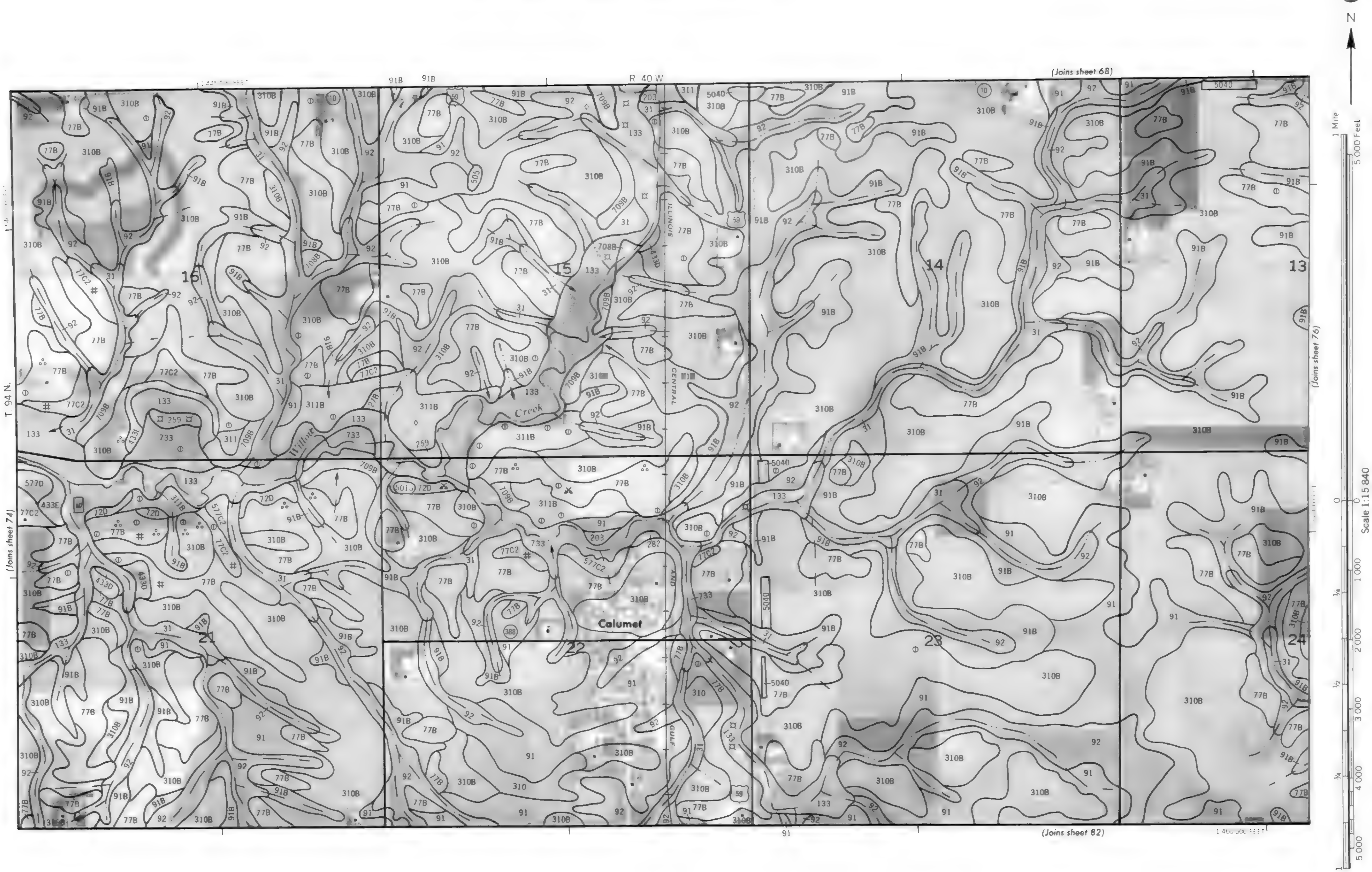

N
(Joins sheet 63)
(Joins sheet 69)
(Joins sheet 77)
R. 39 W.
T. 94 N.
1 480 000 FEET
1 495 000 FEET
INDIAN VILLAGE STATE PARK
WATERMAN
CREEK
Jordan
Creek
Henry
Creek
CLAY COUNTY
1
2
3
10
11
12
Scale 1:15 840
1 Mile
5 000 Feet
0
¼
½
¾
1 000
2 000
3 000
4 000
5 000

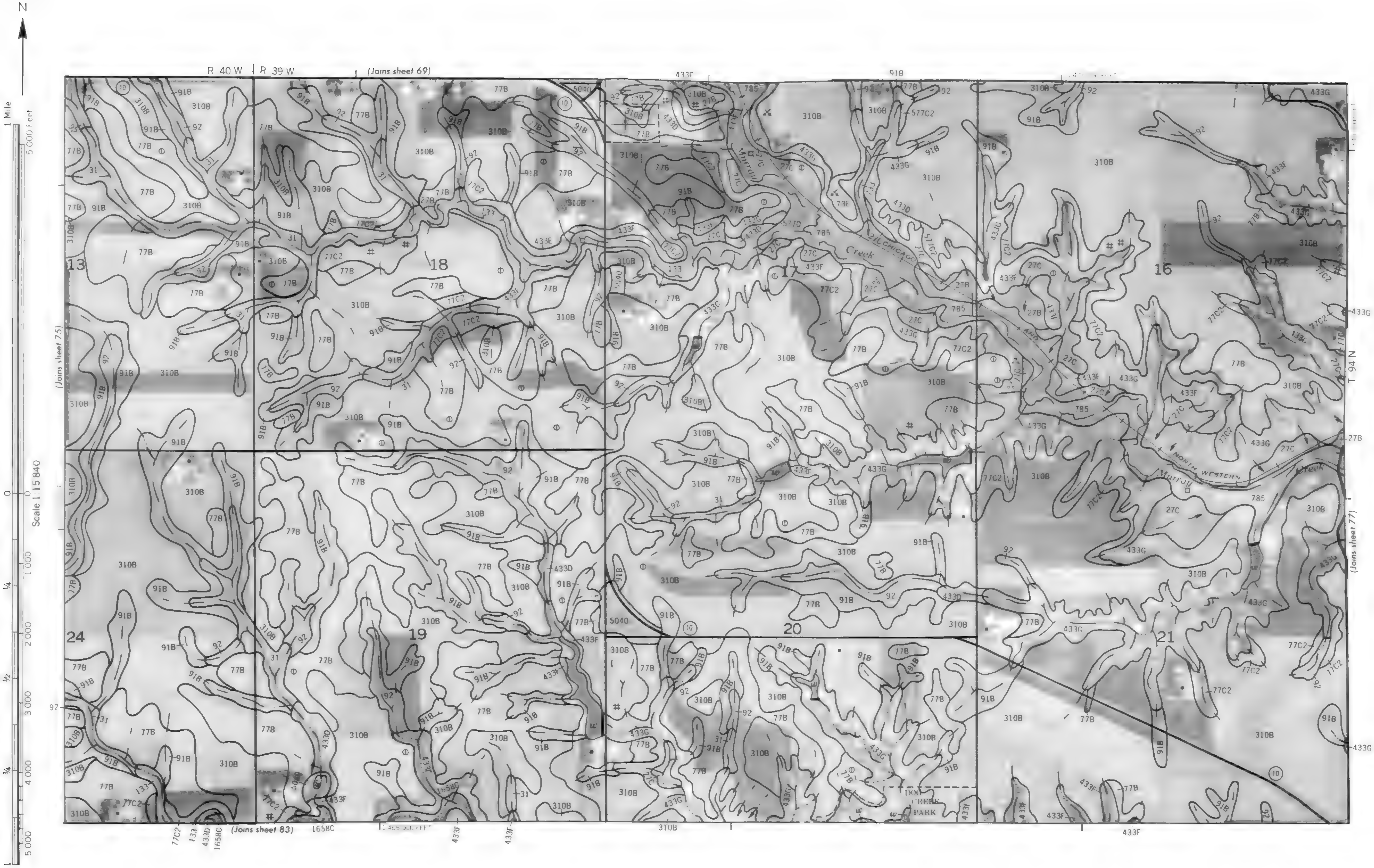

R. 42 W.
(Joins sheet 64)
(Joins sheet 72)
(Joins sheet 78)
T. 94 N.
SIOUX COUNTY
1 370 000 FEET
1 385 000 FEET
15
16
17
18
19
20
21
22
N
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000

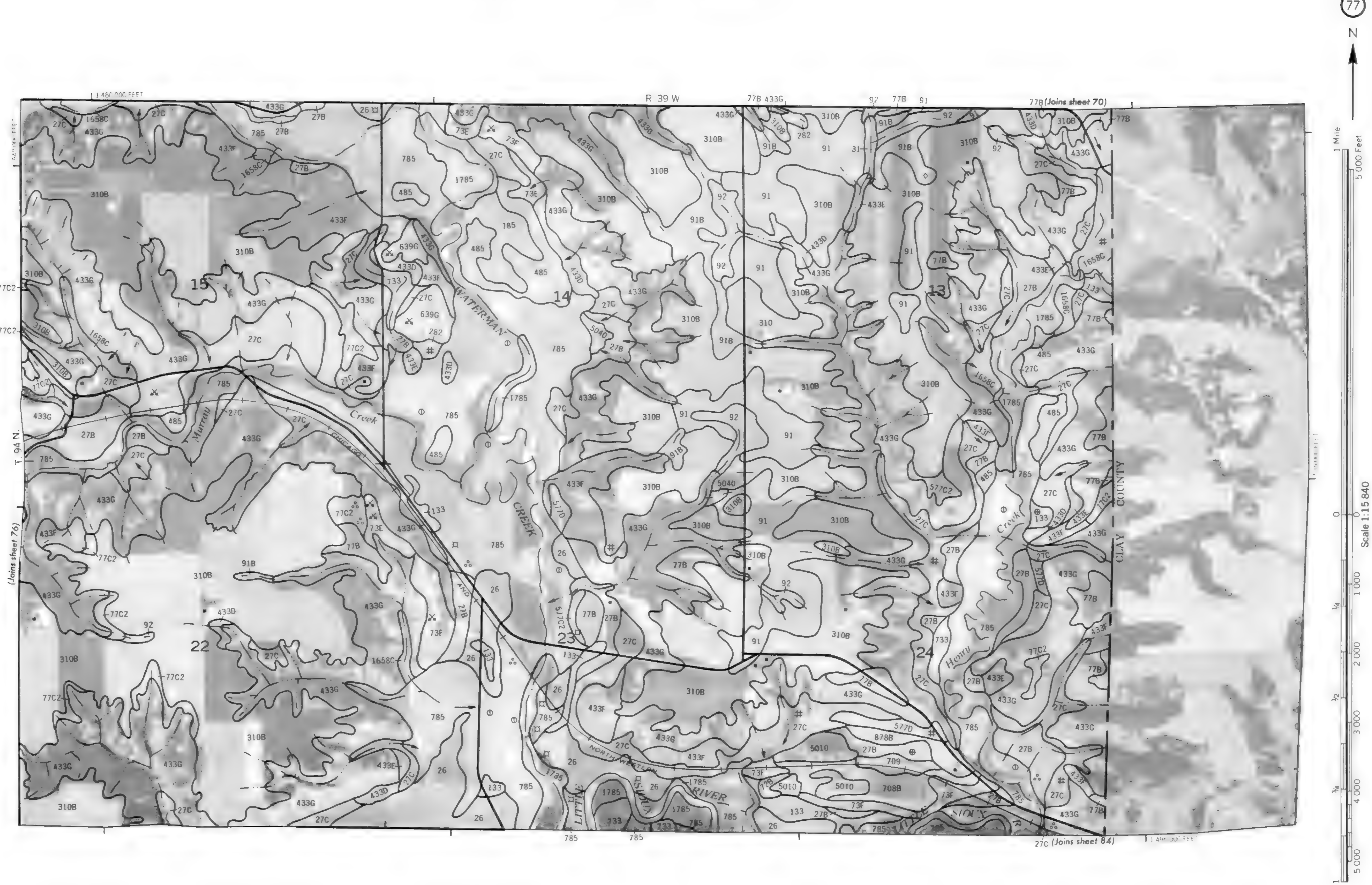

N
(Joins sheet 65)
(Joins sheet 71)
(Joins sheet 73)
(Joins sheet 79)
R 42 W.
R 41 W.
T. 94 N.
1 405 000 FEET
Germantown
Lange
Creek
Lange
Creek
13
14
15
18
19
22
23
24
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000

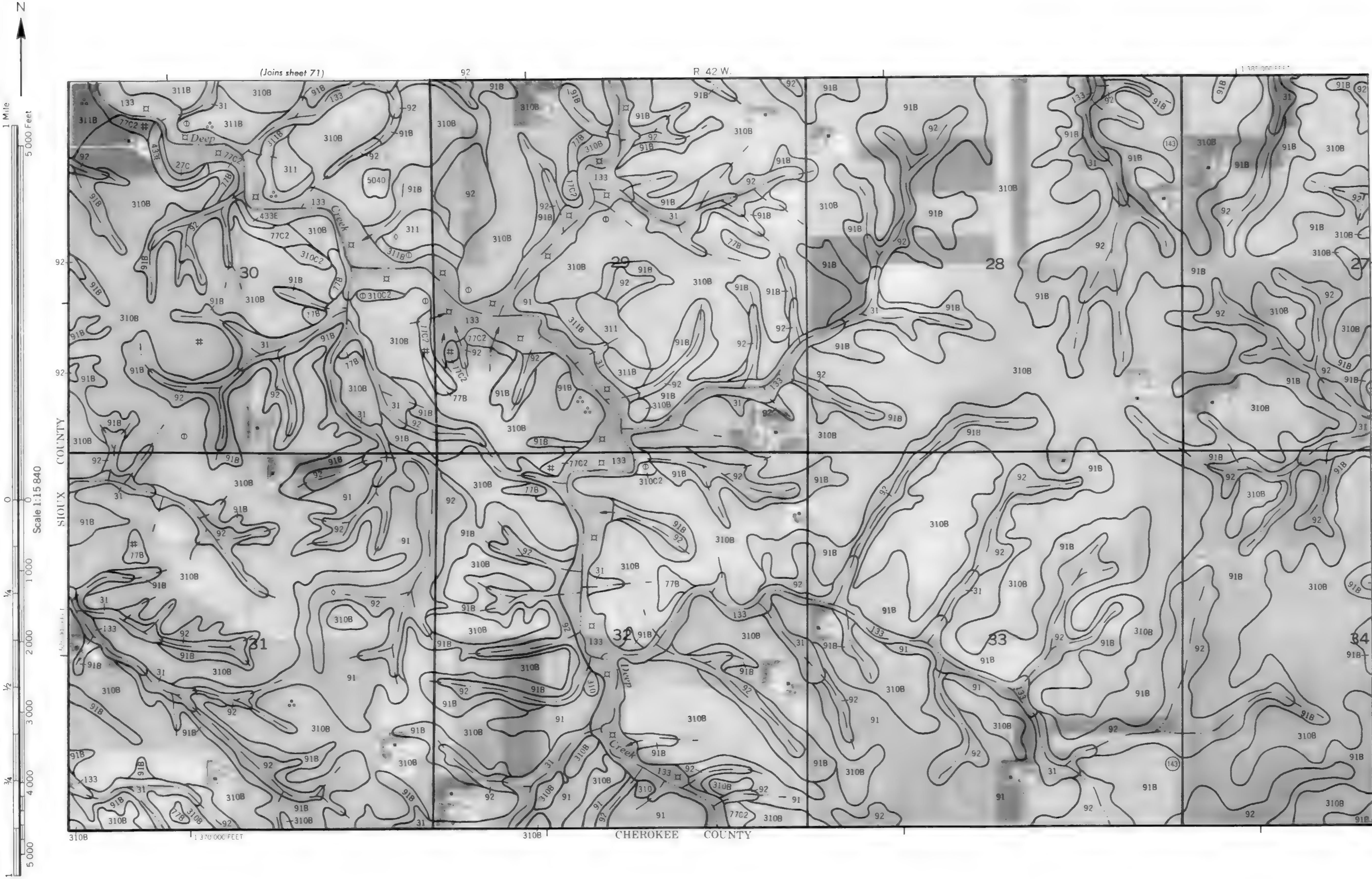

N
(Joins sheet 66)
R. 41 W.
T 94 N
(Joins sheet 72)
(Joins sheet 74)
(Joins sheet 80)
17
16
15
14
20
21
22
23
Mud Creek
Lange Creek
Mill Creek
Nelson Cr.
water
1 Mile
5 000 Feet
Scale 1:15 840

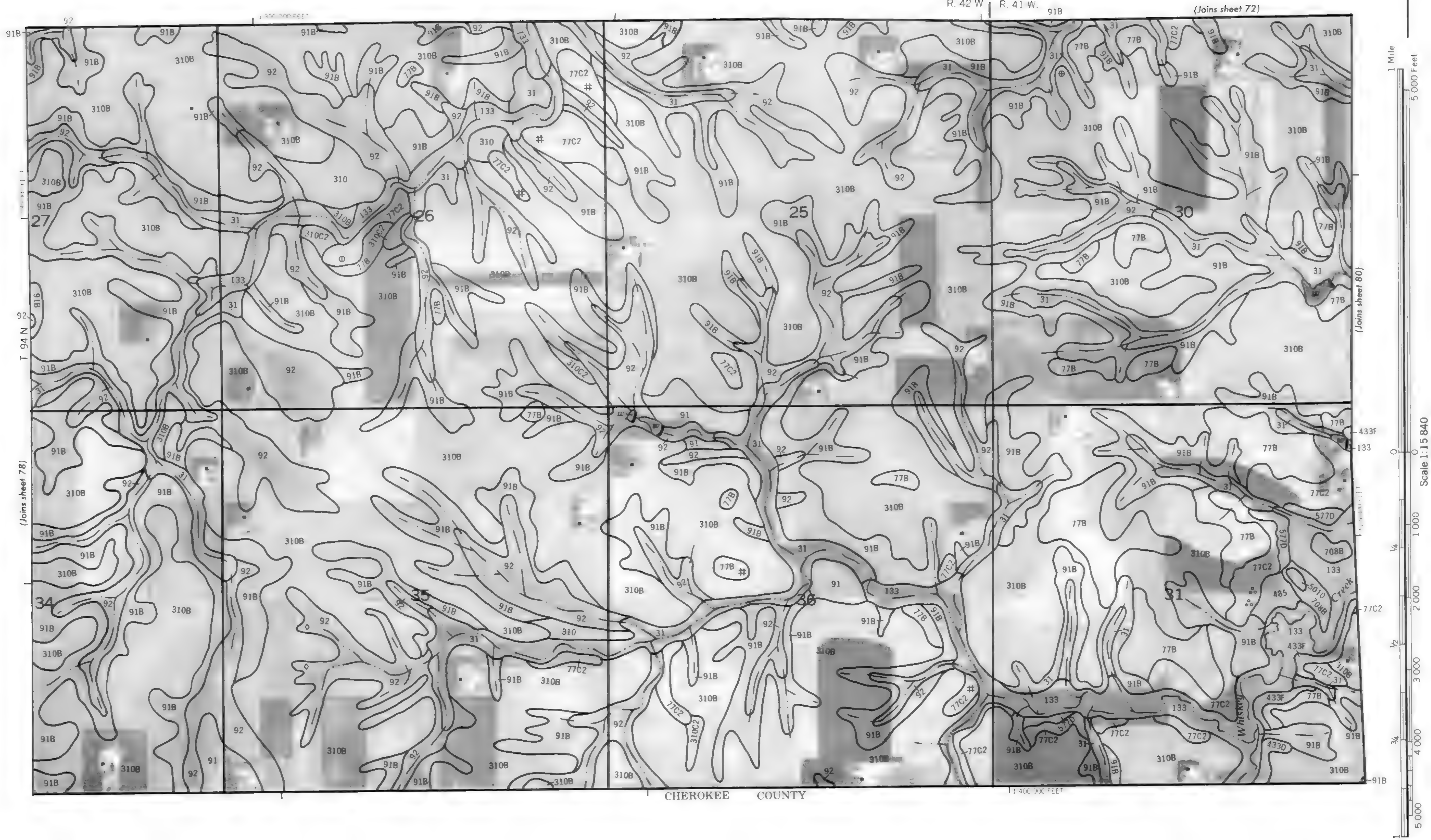

74
N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 67)
R. 41 W. | R. 40 W.
T. 94 N.
(Joins sheet 73)
(Joins sheet 75)
(Joins sheet 81)
14
13
18
17
23
24
19
20
Nelson Creek
Willow Creek

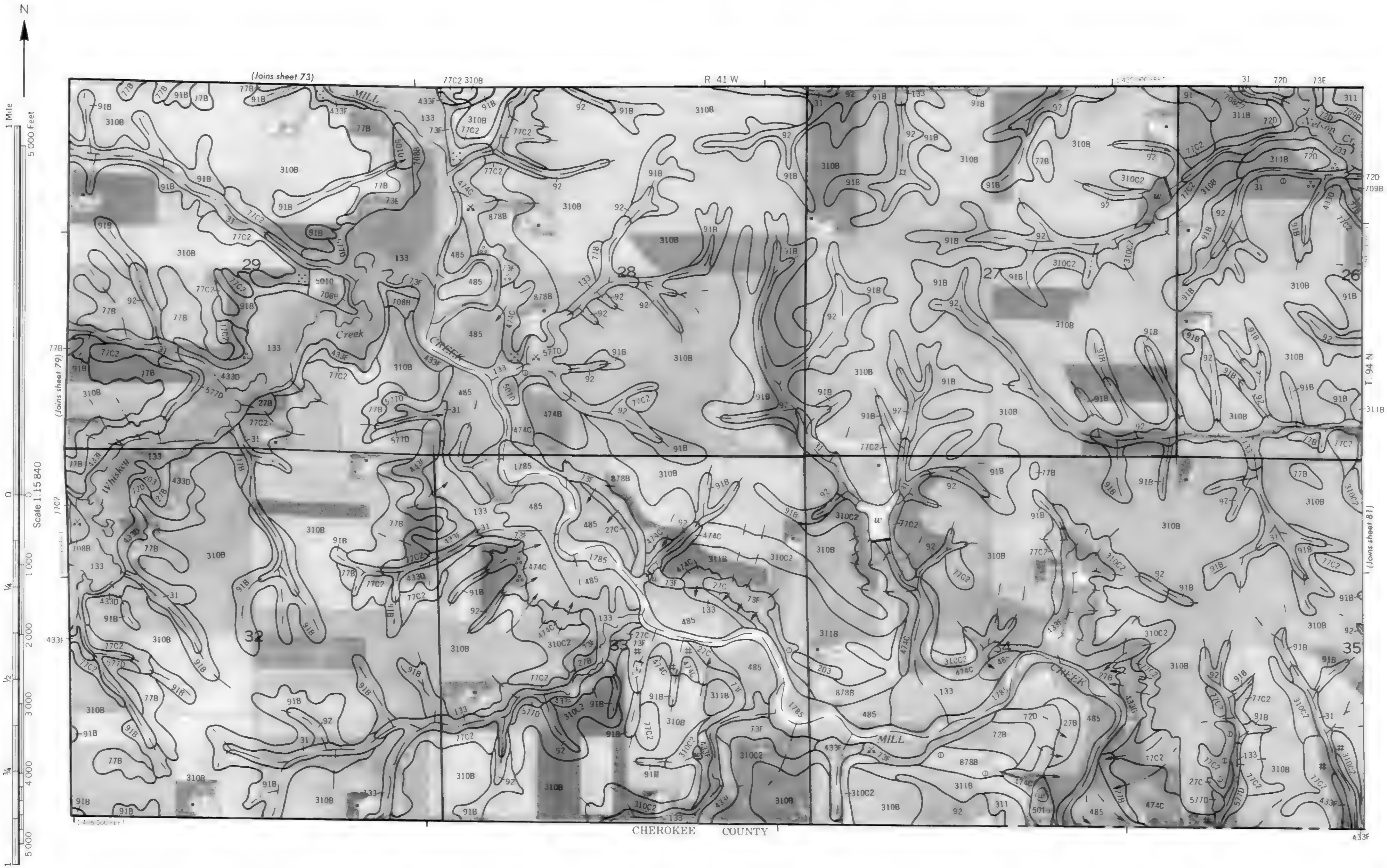

75
N
(Joins sheet 68)
(Joins sheet 82)
(Joins sheet 74)
(Joins sheet 76)
R. 40 W.
T. 94 N.
Calumet
Creek
ILLINOIS
CENTRAL
AND
GULF
15
14
13
16
21
22
23
24
Scale 1:15 840
1 Mile
5 000 Feet
1 Kilometer

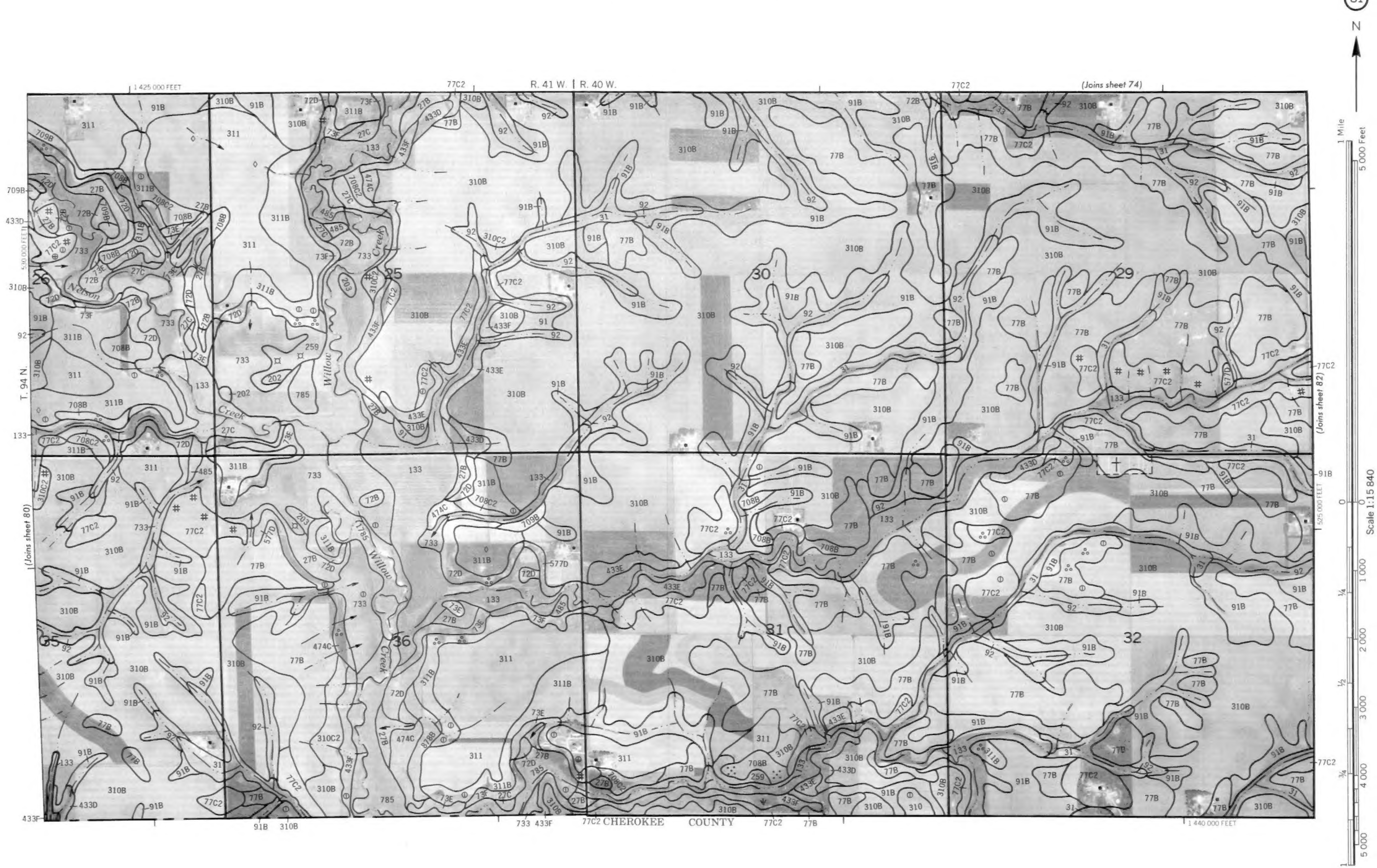

N
1 Mile
5 000 Feet
Scale 1:15 840
R 40 W
R 39 W
(Joins sheet 69)
(Joins sheet 75)
(Joins sheet 77)
(Joins sheet 83)
T 94 N.
13
18
17
16
24
19
20
21
Murray Creek
CHICAGO AND NORTH WESTERN
MILL CREEK PARK

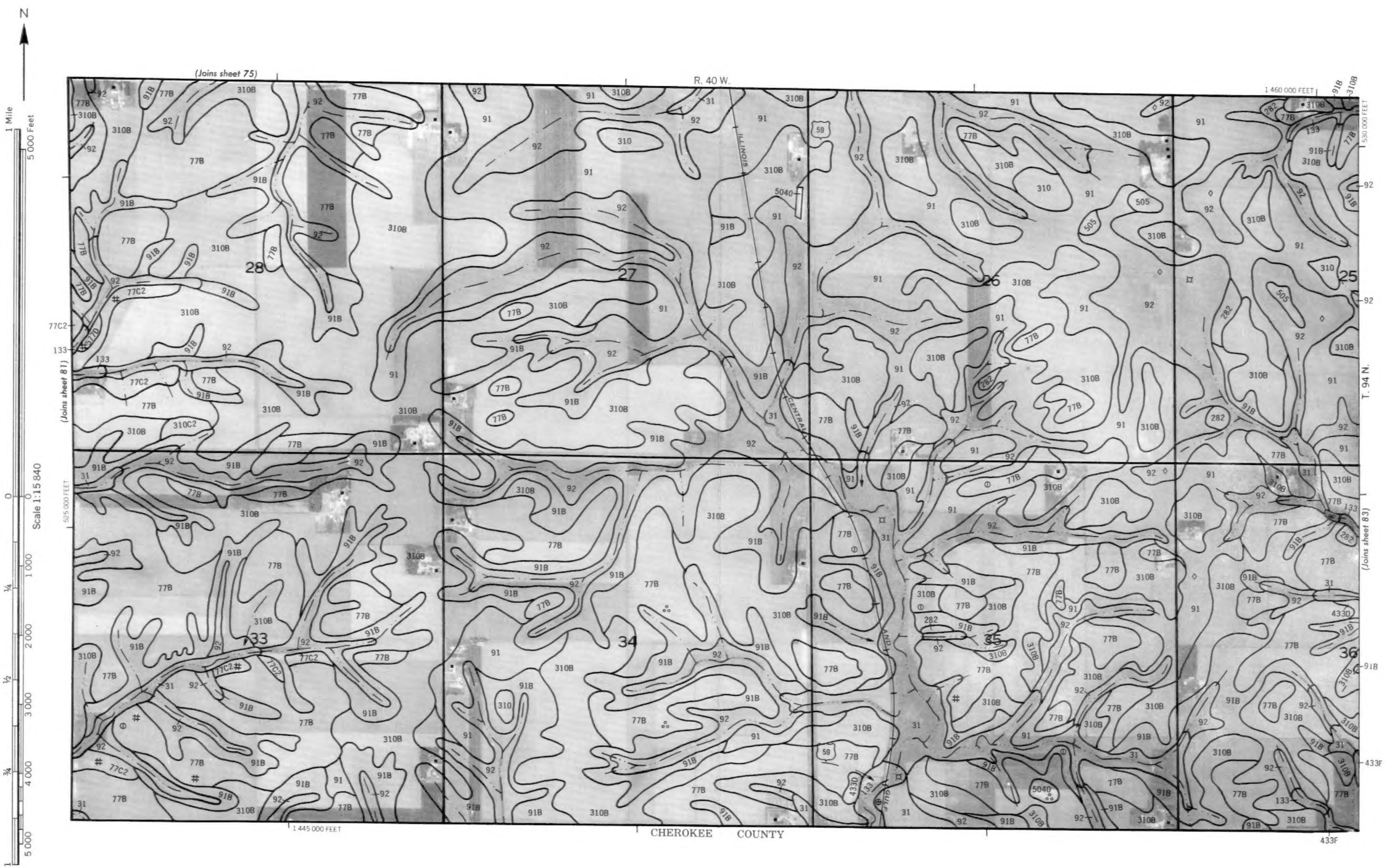

77
N
1 480 000 FEET
R. 39 W.
77B (Joins sheet 70)
T. 94 N.
(Joins sheet 76)
27C (Joins sheet 84)
15
14
13
22
23
24
WATERMAN CREEK
Murray Creek
CHICAGO AND NORTH WESTERN
LITTLE SIOUX RIVER
Henry Creek
CLAY COUNTY
1 Mile
5 000 Feet
Scale 1:15 840
0
¼
½
¾
1
0
1000
2000
3000
4000
5000


N
(Joins sheet 71)
R. 42 W.
T. 94 N.
(Joins sheet 79)
SIOUX COUNTY
CHEROKEE COUNTY
Deep Creek
30
29
28
27
31
32
33
34
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000
1 370 000 FEET


N
R. 42 W.
R. 41 W.
(Joins sheet 72)
(Joins sheet 78)
(Joins sheet 80)
T 94 N
27
26
25
30
34
35
36
31
Whiskey Creek
CHEROKEE COUNTY
1 400 000 FEET
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 73)
R 41 W
T. 94 N
(Joins sheet 79)
(Joins sheet 81)
CHEROKEE COUNTY
Mill Creek
Creek
Whiskey
Nelson Cr.
29
28
27
26
32
33
34
35


N
(Joins sheet 74)
R. 41 W. | R. 40 W.
1 425 000 FEET
530 000 FEET
525 000 FEET
1 440 000 FEET
T. 94 N.
(Joins sheet 80)
(Joins sheet 82)
CHEROKEE COUNTY
Nelson Creek
Willow Creek
25
26
29
30
31
32
35
36
1 Mile
5 000 Feet
Scale 1:15 840
0
1/4
1/2
3/4
1 000
2 000
3 000
4 000
5 000


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 75)
R. 40 W.
1 460 000 FEET
530 000 FEET
525 000 FEET
1 445 000 FEET
(Joins sheet 81)
(Joins sheet 83)
T. 94 N.
ILLINOIS
CENTRAL
AND
GULF
28
27
26
25
33
34
35
36
CHEROKEE COUNTY


N
R. 40 W.
R. 39 W.
T. 94 N.
1 465 000 FEET
1 475 000 FEET
530 000 FEET
520 000 FEET
(Joins sheet 76)
(Joins sheet 82)
(Joins sheet 84)
DOG
CREEK
PARK
Dog Creek
water
25
30
29
28
36
31
32
33
CHEROKEE COUNTY
1 Mile
5 000 Feet
Scale 1:15 840


N
1 Mile
5 000 Feet
Scale 1:15 840
(Joins sheet 77)
R. 39 W.
(Joins sheet 83)
T. 94 N.
1 495 000 FEET
530 000 FEET
520 000 FEET
1 480 000 FEET
LITTLE SIOUX RIVER
Dog Creek
27
26
25
34
35
36
CHEROKEE COUNTY
CLAY COUNTY
BUENA VISTA COUNTY